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The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

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Actions on Standards for Stainless Pipe, Shipping Containers and Masonry Building Units—Brick and Tile

ON NOVEMBER 15 and 16 the Administrative Committee on Standards approved important new Specifications for Austenitic Stainless Steel Pipe (A 312), a new Test for Penetration of Liquids into Submerged Containers (D 998), and several revised specifications and tests for certain masonry building units, as noted in the attached table.

Stainless Steel Pipe:

This new specification has been under development for many months in Committee A-1 on Steel, through the Joint Committee on Stainless Tubing Specifications which is sponsored jointly with A-1 by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. It is intended as a general guide for the purchase of austenitic steel pipe and to serve as a basis for agreement where certain details may not be specifically covered. There are five grades of material involving both seamless and welded pipe which is intended for high-temperature and general corrosive service.

The five grades of material involve Chromium-Nickel (TP 304), Chromium-Nickel-Titanium (TP 321), Chromium-Nickel-Columbium (TP 347), Chromium-Nickel-Molybdenum (TP 316), and Chromium-Nickel-Molybdenum (TP 317). Maximum carbon runs 0.08, per cent manganese 2.00, phosphorus and sulfur 0.030 respectively, with silicon maximum 0.75 per cent. Nickel ranges from 8.0 to 14.0 per cent, with chromium content going from 16.0 to 20.0 per cent.

The minimum tensile requirements are 75,000 psi., with a yield point minimum of 30,000 psi. The longitudinal elongation in 2 in. is 35 per cent, and transverse 25 per cent.

With the establishment of this stainless pipe tentative it is expected that Committee A-1 will make certain rearrangement of its high-temperature specifications so that the stainless grades can all be concentrated in this new document A 312.

A number of A.S.T.M. members have had an active part in reaching an agreement on some of the troublesome points, under the direction of Joint Committee Chairman J. J. B. Rutherford.

Penetration of Liquids Into Containers:

The new Tentative Test for Penetration of Liquids into Submerged Containers, developed in Technical Committee D-10 on Shipping Containers, covers a procedure for determining the amount or extent of penetration of liquids into finished packages or containers when closed and sealed for shipment. The test may be applied to small or shelf-size packages or to bulk size containers as required. The test may be applied to containers as packed or after one or more performance tests such as drum, vibration, drop, or actual shipping tests as required.

Penetration of liquid is defined as the amount or extent of penetration of liquid through (as distinguished from amount, if any, absorbed by the container itself) (1) the sealed closure; (2) the seams of joints included in the structure of the container; (3) the body or walls of the container.

Filter Block, Tile, Brick:

As a result of a rather intensive review in Committee C-15 on Manufactured Masonry Units three tentative specifications have been revised and proposed revisions of three formal standards are to be published prior to their adoption. The requirements on clay block for filters are being clarified so that they will conform more closely to current practice, while the requirements on clay facing tile (C 212) will bring them in line with other standards on structural clay tile and will limit the variations to more satisfactory tolerances.

In order that the tolerances in the Facing Brick Specification C 216 will be in line with those for building brick, and to clarify the requirements on coring, various changes were developed and approved.

All of the above items will be incorporated in the tentatives immediately but those which are noted in the following paragraph are tentative revisions of formal standards and will not be incorporated in the standards until they have been published for a period and then acted upon for adoption.

The proposed revisions on Sampling and Testing Structural Clay Tile (C 112) will clarify the method of determining gross cross-sectional area which, accord-

Actions of A.S.T.M. Administrative Committee on Standards, November, 1948

New Tentatives

Specifications for:
Seamless and Welded Austenitic Stainless Steel Pipe (A 312 - 48 T)
Method of:
Test for Penetration of Liquids into Submerged Containers (D 998 - 48 T)

Tentative Revisions of Standards

Specifications for:
Building Brick (Made from Clay or Shale) (C 62 - 44)
Methods of:
Sampling and Testing Brick (C 67 - 44)
Sampling and Testing Structural Clay Tile (C 112)

Revision of Tentatives

Specifications for:
Vitrified Clay Filter Block for Trickling Filters (C 159 - 45 T)
Structural Clay Facing Tile (C 212 - 46 T)
Facing Brick (Solid Masonry Unit Made from Clay or Shale) (C 216 - 47 T)

ing to the new requirement, reads: "the gross cross-sectional area of a tile shall be determined by multiplying the horizontal face dimension of the unit as placed in the wall by its thickness." This new version is to replace an already-existing tentative revision in Section 12(*a*).

The revisions in Sampling and Testing Brick (C 67) involve clarification of the speed of testing. The proposed new Section 11(d), "Speed of Testing," will read as follows: "The load up to one-half of the expected maximum load may be applied at any convenient rate, after which the controls of the machine shall be adjusted to give a uniform rate of travel of the moving head such that the remaining load is applied in not less that one nor more than two minutes."

Probably among the most widely used building material specifications is the standard covering Building Brick Made from Clay or Shale (C 62). The proposed changes eventually will provide definite requirements concerning the maximum amount of coring and frogging permitted; also set up will be specific variations in dimensions and allowances for dimensions to conform with modular masonry.

Publication of Above Items:

All of the above items will be included in the respective Parts of the 1948 Supplements to the Book of Standards, and the new and revised tentatives will be available in separate pamphlet form. The tentative *revisions* of the three standards will be published in the back portion of the Supplement to Part II of the Book.

New List of Standards Available

MEMBERS who may wish to procure the new 56-page pamphlet listing all A.S.T.M. standards and tentatives as of October, 1948, may do so with a note to A.S.T.M. Headquarters. This *List* of Standards is widely used in connection with inquiries about the A.S.T.M. specifications and tests.

The annual *Index* to Standards, a 260-page book, will be sent to members early in the spring. This Index notes where all of the standards are published. The *List* (available on request as noted above) simply gives the latest titles and designations.

1949 Spring Meeting and Committee Week in Chicago Week of February 28

Meetings at Edgewater Beach Hotel; Chicago District Planning Dinner and Entertainment

PLANS are nearing completion for the 1949 National A.S.T.M. Spring Meeting to be held at the Edgewater Beach Hotel in Chicago on Wednesday, March 2. It is probable that the technical feature of this Spring Meeting will be a symposium under the auspices of Committee D-11 on Rubber and Rubber-Like Materials covering the aging of rubbers.

Throughout this week beginning February 28 and extending through March 4, A.S.T.M. Committee Week will be in progress with a large number of meetings of main A.S.T.M. technical committees and their subcommittees and sections.

Dinner and Entertainment:

The Chicago District Council will act as host during the Spring Meeting and is planning to have a subscription dinner at the Edgewater Beach on Wednesday night, March 2. While final plans have not yet been decided the Council is considering an evening of entertainment rather than having a dinner speaker or a series of papers or addresses. An outstanding local musical organization has been invited to sing at the dinner and there will be shown some interesting colored slides having to do with the field of natural history. Further details cannot now be given but an entertaining and pleasant evening will be in store for all A.S.T.M. members and their friends who will be in Chicago at this particular time.

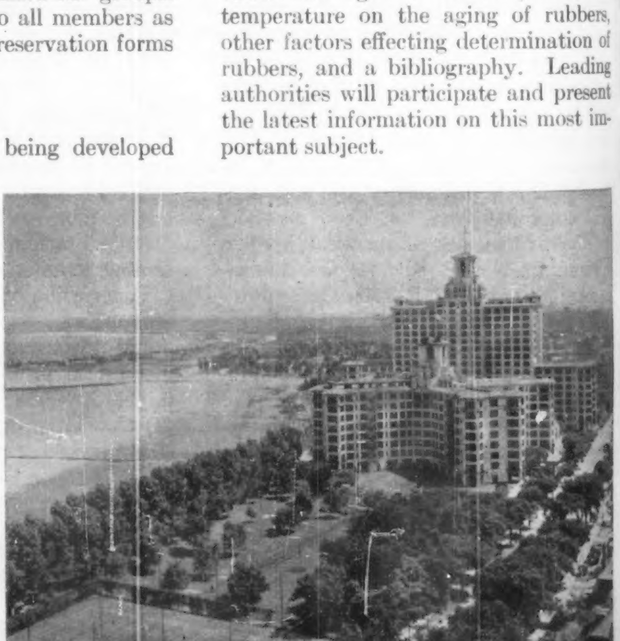
Committee Week:

Already a good many of the A.S.T.M. technical committees have indicated their intention of holding series of meetings during 1949 Committee Week. By careful scheduling of the meetings to keep a conflict of interests and membership to a minimum, Committee Week conserves the time and travel expense of those committee men who are active in the work of several A.S.T.M. groups.

There will be sent to all members as soon as possible hotel reservation forms and further details.

Aging Symposium:

Several papers are being developed for the symposium on aging of rubbers but it is too early to announce specific details. Subjects which will probably be covered include mode of attack of oxygen on rubbers, oxygen absorption methods and their utility and limitations in the study of aging, chemical changes which take place in rubbers and age resistance, physical aspects of the aging of rubbers, etc.; also aging effects of ozone and light on rubbers, effect of temperature on the aging of rubbers, other factors effecting determination of rubbers, and a bibliography. Leading authorities will participate and present the latest information on this most important subject.



Edgewater Beach Hotel, Chicago

Annual Meeting in Atlantic City Week of June 27, 1949

Numerous Technical Features Planned Including Symposiums and Sessions on Durability of Bituminous Materials, Testing Cast Iron, Ultrasonic Testing, Bearing Metals and Lubricants, Radiography, and Others

IN ADDITION to some very interesting and unquestionably outstanding technical symposiums and sessions to feature the program of the 1949 Annual Meeting in Atlantic City, certain of these features being noted below, there will be the usual heavy schedule of committee meetings. No apparatus exhibit will be held and it is not anticipated that there will be a photographic competition in 1949.

Chalfonte-Haddon Hall, which has been the scene of so many successful A.S.T.M. meetings, will be the host hotel again during the last week of June, beginning June 27.

All members will receive advance hotel reservation blanks in the spring, and subsequent BULLETINS will give more information about features of the meeting. While A.S.T.M. annual meetings always are very intensive periods for most of the members, with numerous committee meetings and technical sessions, and exhibits to visit when the exhibits are held, there is usually an opportunity for some relaxation, and at Atlantic City the "old" boardwalk is right at hand for a bit of exercise or window shopping, etc.

Excellent meeting facilities are available at Chalfonte-Haddon Hall, and this aids in efficient scheduling of the various features of the meeting.

Technical Features

BRIEF notes on some of the symposiums and sessions scheduled for the meeting are given below. More detailed information will be given at a later date, and of course the Provisional Program for the meeting which gives a very complete advance picture of the technical features will be published in the May BULLETIN, or distributed separately as far in advance of the meeting as possible.

Symposium on Accelerated Durability Tests of Bituminous Materials:

This symposium is being developed under the joint auspices of Committees D-4 on Road and Paving Materials and D-8 on Bituminous Waterproofing and Roofing Materials. This should be a very worth-while symposium as there is a vital need for material on this subject.

Symposium on Testing of Cast Irons with SR-4 Type of Gage:

This subject is being sponsored by Committee A-3 on Cast Iron to promote the study of stresses in castings by nondestructive methods such as the SR gage, etc. It is believed that such a program will serve to illustrate methods for testing castings in a nondestructive way which should lead toward the advancement of their usage in industry.

Symposium on Ultrasonic Testing:

At the annual meeting of the Society held in Detroit last year, Committee E-7 on Non-Destructive Testing sponsored an informal discussion on ultrasonic testing. Because of the intense interest that was expressed in this subject, the committee is sponsoring a session to be held at this year's annual meeting. It is proposed to have four papers on the subject, the first of an introductory nature, the second on theory, and the other two on practical applications.

Session on Radiography:

Committee E-7 on Non-Destructive Testing is planning also to sponsor a session on radiography to include papers on the recent progress in high-speed flash radiography, initial experience with the first industrial type mobile betatron, X-ray moving pictures, and a portable two million volt find focal spot X-ray generator. The paper by Messrs. Van de Graaf, Feshbach, Bur-

"Vickers Hardness Test on Hot Metals" Honorable Mention, Testing Equipment Group, General Section, in the Sixth A.S.T.M. Photographic Exhibit, by William W. C. Wilke, Jr., Crane Co. Research Laboratories.

rill, Sperduto, McIntosh, and Buechner on "An Investigation of Radiography in the Range from 0.5 to 2.5 Million Volts" which appears in this issue of the BULLETIN will serve as an excellent introduction to the above-mentioned papers.

Symposium on Sleeve Bearing Metals and Their Lubricants:

In view of the evolution and applications of the various bearing metals in fields such as machine tools, railroad, automobile, aircraft, etc., the Administrative Committee on Simulated Service Testing is now developing a symposium on this subject. A feature of the symposium will be emphasis on the compatability of lubricants used with various types of metals in this field.

General:

In addition to the formal symposiums, there will be the usual sessions devoted to specific topics such as: concrete and concrete aggregates, corrosion, fatigue, etc.

Symposium on Exhaust Valve Burning:

Technical Committee B on Lubricating Oils of Committee D-2 on Petroleum Products and Lubricants is planning to hold a symposium on exhaust valve burning which will consist of three of four papers on the subject. This is now under development and more information will be available at a later date.

National A.S.T.M. Meeting on West Coast—October, 1949

AS PREVIOUSLY announced, the Society is having its first national meeting on the West Coast in October, 1949, the affair to be in San Francisco during October 10 to 14, with convention headquarters at the Fairmont Hotel.

The Northern California District Council, headed by Dozier Finley, Research Consultant, the Paraffine Cos., Inc., is the nucleus for the local committee on arrangements which will include representatives, however, from the Southern California District centering in Los Angeles, and also members from other West Coast states.

This committee is to set up various working groups which will cover the necessary meeting activities.

The technical program is being developed by a committee headed by R. E. Davis, Professor of Civil Engineering, and Director, Engineering Materials Lab., University of California, Chairman, and J. W. Kelly, University of California, Secretary. This group had an extended meeting this fall, and a few notes on the technical program as it is being considered and developed by this group will be of interest. However, some of the plans are necessarily tentative at this time and further details will be given the members through the BULLETIN and in other announcements from time to time.

The Program Committee, as part of its plan of operations, is anticipating that the large number of authors who will present papers will discuss applications rather than basic theory. The topics and discussions will be aimed in large part at the "general" A.S.T.M. member rather than specialists in particular fields.

There will be a number of contributions dealing with the application of statistics and ceramics, and concrete products will be covered, and certain discussions will relate to dynamic stress determinations. There are two sessions to be in the field of metals, one involving formability and creep, and the second, fatigue.

In the field of paints, it is anticipated there will be three papers covering plywood finishes, testing of paint, and aircraft finishes, with an ensuing luncheon meeting and summary in the afternoon involving the work of Committee D-1.

The Program Committee is planning two sessions in the field of petroleum products, and soils, asphalt, cement and concrete will be dealt with in possibly three sessions. There will be certain papers dealing with wood and timber.

Advice has already been received from a number of A.S.T.M. Technical Committees that they plan to hold meetings in San Francisco during October, 1949.

"Warm in Winter • Cool in Summer" San Francisco!

THE Convention and Tourist Bureau has the following to say about its unusual city. From time to time other notes about the West Coast will appear in the BULLETIN.

SAN FRANCISCO—America's most cosmopolitan city. There is much to see, much to do, in this fascinating metropolis. Here are a few of the things you must not miss:

The Golden Gate Bridge . . . World's longest single span. An ocean liner passing below on its way out the Golden Gate into the Pacific.

Swing aboard one of the cable cars and high you go, up the hills. Buy flowers from the colorful sidewalk flower stands, Explore fabled Chinatown—where America seems suddenly to be six thousand miles away. Visit the Oriental telephone exchange where calls are given by the twenty-four hundred subscribers' names instead of by numbers.

Don't miss Fisherman's Wharf—a bit of Naples to the eye, a bit of heaven to your nostrils if you love fresh seafood. Drive on down the Marina, view the gay boats in Yacht Harbor. Survey the city by night atop Telegraph Hill where you can see both great bridges, Alcatraz (seemingly so close!), Treasure Island, Russian Hill, Nob Hill—all of the city spread before your feet.

You shouldn't leave San Francisco without a visit to the Golden Gate Park whose thousand acres are a paradise reclaimed from the sand dunes. This, the place where a local newspaper in 1880 said, "a blade of grass cannot be raised without four posts to support it," is now one of the

beauty spots of the world—a garden of drives, lakes, and groves. Here can be found the De Young Museum, rare and colorful tropical fish in the Steinhart Aquarium, the remarkable African collection of animals in the adjoining Academy of Sciences Building. You would not want to miss a walk through the nearby Oriental Tea Garden. We suggest that you stop there for a cup of tea. If you have the time, drive on out to Fleishhacker Pool (the largest outdoor swimming pool in the world and walk through the magnificent zoo next to it. Return downtown by way of the residential districts, taking the winding road up to Twin Peaks—the lookout place that shows you all the city and the surrounding Bay and Mt. Davidson, highest of San Francisco's peaks. Stop at Mission Dolores, the church where San Francisco was born, for a quiet restful visit to the past.

Fine food is traditional in this city. Every nation is represented. One may truly "eat around the world in San Francisco." French, Italian, Swedish smorgasbord, German, Russian Spanish, Chinese, and Japanese. Enrico Caruso put it best. Saturated in San Francisco food once, he sighed: "There is a diabolical mystery to your San Francisco. Why isn't everyone fat?" You will have to discover the restaurants that please you, you must explore our magnificent hotels, you must take the time to find that part of San Francisco that pleases you best. It will take much longer than the four days you have alloted for this visit. May we ask that you—Please Come Again?

Notes on New Publications

SEVERAL significant new A.S.T.M. publications comprising technical papers and reports and certain compilations of standards were noted in the October ASTM BULLETIN. These included the Forum on Tractor Fuels, Symposium on Mineral Aggregates, and the Symposium on Spectroscopic Light Sources. The compilations of standards covered such fields as textile materials; plastics; electrical heating, resistance, and related alloys; mineral aggregates, concrete and nonbituminous highway materials; bituminous materials for highway construction, waterproofing and roofing; and copper and copper alloys.

All of these publications were listed on the Members Order Blank which was distributed to each member in November.

Several other new publications have recently come off press, or are scheduled for completion soon, all of which will be of widespread interest to broad segments of the membership. In fact, one of the publications noted below should be of interest to each member and committee member, this dealing with the usefulness and limitations of samples.

In addition to the technical books and standards compilations, a new A.S.T.M. Year Book, a most important publication, has also been issued.

All of the A.S.T.M. special publications can be procured by members at reduced prices.

Symposium on Methods and Procedures Used in Identifying Reactive Materials in Concrete

This Symposium held during the annual meeting under the auspices of Committee C-9 on Concrete and Concrete Aggregates includes six technical papers by outstanding workers in this field. The question of reactivity has come to the fore rapidly in recent years and a great many A.S.T.M. members have been concerned with the subject and have studied it, and the two technical committees C-9 and C-1 have also officially had the subject on their dockets.

In connection with this interesting symposium described below, it is of interest to note that the Sanford E. Thompson Award, which is sponsored by Committee C-9 and given to an author of an outstanding paper in this field presented at an annual meeting of the Society, was this year awarded to W. C. Hanna, long-time member and officer of A.S.T.M., for his paper on "Unfavorable Chemical Reactions of Aggregates in Concrete and a Suggested Corrective" in the 1947 *Proceedings*.

The six papers in the current symposium, now on press, are as follows:

Correlation of Laboratory Tests with Field Experiences of Excessive Concrete Expansion Induced by a Reaction Between the Cement and Aggregate—Thomas E. Stanton, California Division of Highways.

A Wetting and Drying Test for Predicting Cement-Aggregate Reaction—C. H. Scholer, Kansas State College of Agriculture and Applied Science.

Correlation of Laboratory Tests with Field Experience in Alkali-Aggregate Reaction—Bailey Tremper, State of Washington Department of Highways.

Tests Used by Bureau of Reclamation for Identifying Reactive Concrete Aggregates—R. C. Mielenz and L. P. Witte, Bureau of Reclamation.

A Rapid Method of Testing Materials for the Alkali-Aggregate Reaction—D. O. Woolf and T. R. Smith, Public Roads Administration.

Petrographic Identification of Reactive Constituents in Concrete Aggregate—Bryant Mather, Corps of Engineers.

Certain excerpts from the Introduction to the Symposium will aid in showing the coverage of this publication.

"Many instances are known of unfavorable reaction which has been the cause of cracking in large structures. Many articles have been written discussing the possibility of reaction between alkali set free in the hydration of cement and certain minerals occurring in the concrete aggregate and has been shown through experience that certain combinations of cement and of aggregate cause failure in concrete through excessive chemical reactivity.

"Research has been pointed toward ways and methods of identifying potential reactive materials before they are actually in combination in a concrete mass. Two technical committees of the Society—Committee C-1 on Cement and Committee C-9 on Concrete and Concrete Aggregates—have a vital interest in this field of research from the standpoint of their respective interest in both cement and aggregates as well as their common interest in concrete. Subcommittees in both have inaugurated extensive studies and for the past two years have been meeting jointly at which time forums have been conducted including the presentation of papers on methods of testing reactive materials.

"There are a number of ways of identifying potentially reactive materials. However, none of them has been developed sufficiently to warrant consideration as suitable for an A.S.T.M. Standard. Several of these methods have had extensive practical use and now seems a good time to compare them for simplicity of determination and correlation with actual findings in the field to the end that a suitable method may be standardized by the Society. Committee C-9 has arranged this symposium in the hope that the facts revealed will be of assistance in the preparation of a standard method or methods.

"There are two papers written by Bailey Trempor and Thomas E. Stanton, respectively, dealing with the correlation of laboratory tests with field experiences. Both papers describe the use of mortar bar expansion tests and their correlation with field experience. In one case good durability is indicated when low-alkali cement is used with a certain source of aggregates and the other to indicate the potential adversely reactive properties of a portland cement fine aggregate combination.

"The paper presented by D. P. Woolf and T. R. Smith describes a simple and rapid method of testing mortar or concrete for the alkali-aggregate reaction by the Mason jar test. This method was developed to offset the principal disadvantage of the mortar bar expansion tests which was that of the time required to complete a test. An acceleration of the reaction by the alkali in the cement and

the aggregate was accomplished by the addition of one per cent of sodium hydroxide by weight of the cement to the mortar.

"The methods used by the Bureau of Reclamation are referred to in the paper presented by R. C. Mielenz and L. P. Witte. These methods comprise (a) petrographic examination and analysis, (b) a chemical test with NaOH solution, (c) tests of mortar and concrete containing the aggregate under investigation and cements of various alkali content, and (d) field and laboratory investigation of concrete in structures.

"The petrographic identification of reactive material was described by Bryant Mather. It is suggested in this paper that the techniques of petrography be used to determine the presence or absence of any of the known reactive materials in concrete aggregates as well as providing a check on the results obtained by other tests."

Copies of this 80-page publication in heavy paper cover can be obtained by members at $1.15; list price to non-members being $1.50.

Samples (they're important!)

This Symposium on the Usefulness and Limitations of Samples is the first to be presented under the auspices of Committee E-11 on Quality Control of Materials. This very active technical committee was organized about two years ago to promote the knowledge of quality control methods and their application to A.S.T.M. problems. Here, by quality control methods is meant those methods that have been developed on a statistical basis to control the quality of product through the proper relation of specification, production, and inspection as parts of a continuing set of operations.

Harold F. Dodge, Chairman of Committee E-11 in his Introduction to this most interesting symposium points out that the committee has had some pressure brought to bear on it to hold technical session on subjects that were under consideration. What is wanted is discussions of topics at the engineer's level. In line with this the Committee enlisted the aid of two of its members, Arthur W. Carpenter, and A. G. Ashcroft, who are well known for their practical mindedness, and this team elicited papers from three experts on techniques of quality control but more important experts in the art of getting ideas across to others.

"All of us when dealing with materials are continually up against the problem of sampling and of making use of results obtained from samples of one kind or another. At any one time we may be faced with one of two general types of problems. First, what is the quality of this specific batch of material that is before us now, how closely may we determine its properties, and how shall we interpret the test results in making a decision regarding its disposition? Second, how is the manufacturing process, which is turning out this material, behaving? Is it essentially stable or is it subject to erratic variations? Can something and should something be done to the process to provide greater uniformity?

"We try to solve both types of problems by taking data, but many questions arise, both in the collection and in the analysis of data, which must be answered. How do we go about sampling bulk material as distinct from a product made up of individual pieces or articles? If the material sampled is not homogeneous, and it usually is not, how should we spread our sample over the whole? Having obtained a given set of data, how reliable are our results? How large an error may have been introduced because of the size of our sample and because of the method of sampling?

"Then again, we know that our test data are subject to two influences: first the variations in the material itself, and second, the variations due to the testing operation. The question often arises: How much of the total variations is attributable to material and how much to testing?

"Further, as we make tests on successive consignments of material from different sources, we often have the question: How much testing is necessary so that good material will generally be accepted and poor material rejected? If material from any one source is consistently good, are there any general principles governing the degree to which we can reduce the amount of testing as compared with that required when the quality is erratic?

"These are some of the questions with which we are continually confronted and there are certain general principles that may be used as guides in determining the character and quantity of numerical data that should be obtained under a given set of conditions.

"The three papers in our program consider some of these broad questions and indicate ways in which the methods of statistics can be of aid to us as engineers in answering them. Probability laws are invoked, but consideration is given to the use of empirical criteria that are suited to the world of experience."

The three papers in the Symposium are as follows: "Sampling and Its Uncertainties," S. S. Wilks, Professor of Mathematical Statistics, Princeton University; "Variation in Materials, Testing, and Sample Sizes," Leslie E. Simon, Colonel, Ordnance Dept., Director Ballistic Research Laboratories; and "The Amount of Inspection as a Function of Control of Quality," G. R. Gause, Bell Telephone Laboratories, Inc.

Standards on Petroleum Products and Lubricants

This November, 1948, compilation covering Standards on Petroleum Products and Lubricants with considerable other related information is the most extensive special compilation the Society has ever issued. Covering some 760 pages it gives, with few exceptions, all of the large number of test methods and the special other standards developed by A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. The exceptions not included in this compilation are the methods of tests for knock rating of engine fuels which are published in a Knock Test Manual issued earlier this year, with an appendix scheduled for publication within the next six weeks to bring the Manual up to date.

There are large groups of standards covering motor and aviation fuels; diesel and burner fuels, kerosine and illuminating oils; lubricating oils; greases; plant spray oils and petroleum sulfonates; electrical insulating oils; light hydrocarbons; hydrocarbon solvents; asphaltic materials; crude petroleum; and thermometers.

Several appendices add to the value of this new compilation, and in addition to the Annual Report of Committee D-2, with a supplementary report, proposed methods are given covering: performance characteristics of wheel bearing grease; separation of residue from butadiene; butadiene dimer in polymerization grade butadiene; nonvolatile residue of polymerization grade butadienesodium in lubricating oils and lubricating oil additives; measuring the temperature of petroleum and petroleum products; analysis of calcium and barium petroleum sulfonates; and benzene and toluene by means of ultraviolet spectrophotometry. Also given are proposed factors and tables for volume correction and specific gravity conversion of liquefied petroleum gases; optional use of detonation meter for

New List of Publications Sent with Members Order Blank

LATE in November, there was transmitted to each member and committee member of the Society a new booklet describing A.S.T.M. Publications. This gave brief descriptions of many of the newer books and also noted some of the ones published earlier, but still in demand. Each member or official representative of a company membership received a Members' Order Blank which enabled purchase of the books at the special prices to members. The committee members received an appropriate order blank and related information. To both groups was sent a special blank listing numerous technical papers that are being printed in advance of their appearance in the *Proceedings*.

The various publications ordered by the members will be sent just as soon as they become available.

motor and research methods; and a proposed method of test for sulfur in petroleum oils by quartz tube combustion.

Copies of this 760-page book in heavy paper cover can be procured by members at the special price of $4.25, or in cloth binding at $4.90. List price for paper cover is $5.50.

1948 Year Book Extensive

THE 1948 Year Book, just off press, and in course of distribution to the members, is not only a most extensive but an extremely interesting publication. It is the only place where one can get any kind of a true concept of the great extent of the A.S.T.M. technical committee structure, and the section on geographic distribution of the members really demonstrates that A.S.-T.M. is a world-wide organization.

A large portion of the new Year Book is devoted to the detailed listing of members giving titles, connections, addresses, etc. Compared with this section of about 160 pages is the portion devoted to committee personnel aggregating over 240 pages.

In addition to these sections there is pertinent information about the Society, a list of Honorary and Sustaining Members, information on Forty-year members and those deceased. There are data on past and present officers, Charter and By-laws are included, and various Regulations Governing the Board of Directors, Technical Committees, Papers, Committee Reports and Discussions, Recommendations on the Form of Standards, and data on various awards.

This 1948 Year Book is being sent to all members whose requests are on file. At the present time about 70 per cent of the members have requested copies.

1948 Standards Supplements (Five Parts) Being Issued in December-January; 1949 Book to be in Six Parts

THE 1948 Supplements to the 1946 Book of Standards, which Supplements are issued in heavy paper binding, there being a separate supplement for each of the five Parts of the '46 publication, are rapidly nearing completion, and mailing of some of the Parts can be started in December. It is expected that Part II on Nonmetallic Materials—Constructional will be the first one off press in December, the others following closely until the last, Part I-A on Ferrous Metals, which is scheduled for early January. These Supplements will be sent to members in accordance with the instructions on file at headquarters, and purchasers of the Book of Standards and the 1947 Supplements will be given further information on the '48 publications, whether they be members or nonmembers.

Six Parts in 1949 Book:

Because of the greatly increased size of the 1949 Book of Standards, which will combine all material in the '46 Book and the two subsequent Supplements, and the new material to come through next year, six Parts will be necessary. The present Parts I-A, I-B, III-A, and III-B will remain essentially unchanged except that the material on shipping containers and adhesives now in Part III-B will be shifted to a new Part 4. The present 1946 book covering Nonmetallic Materials—Constructional, Part II, will be divided into the two following parts:

Part 3:

Cement
Concrete, Aggregates, and Nonbituminous Road Materials
Refractories
Glass
Other Cementitious Standards
Bituminous Road and Waterproofing Materials
Soils
General Test Methods

Part 4:

Paint and Naval Stores
Wood and Wood Preservatives
Adhesives
Shipping Containers
Fire Tests of Materials
General Test Methods

After careful study of the increased size of the 1949 Book, the considerably increased costs involved including printing cost, the Board of Directors, as announced in the October BULLETIN page 9, has instituted somewhat increased charges to the members for the various Parts of the Book. The scale of charges to members will be as follows:

For 1949 Standards (also '50, '51 Supplements)	Annual Charge
Any one part	No charge
Any two parts	$4
Any three parts	$5
Any four parts	$8
Any five parts	$10
All six parts	$12

The new scale in general represents an increase of only $2 for those members (about half of our members) who have been getting two or more parts including the present Part II, and who will now wish to get each of the books into which Part II will be divided, that is, new Parts 3 and 4. Thus, members who wish to continue to obtain the *complete* Book of Standards will pay $12 instead of the present $10. In the case of members who have been obtaining Part II *only*, without charge, and will now wish to procure both the new Parts 3 and 4, there will be an annual charge of $4, just as there has been a like charge for the past two years to all members who had originally secured former Parts I or III when each of those parts was split in 1946 into two books.

The October BULLETIN included a note asking members to review their requirements for the Book of Standards and to advise the Executive Secretary of any changes to be made in their instructions which are now on file at headquarters concerning the Parts desired.

Unless otherwise advised the members will receive those Parts of the 1949 edition of the Book corresponding to present instructions. Those members who have been receiving Part II will get new Parts 3 and 4.

The Book of Standards, which has grown tremendously in the past ten to fifteen years, continues to be one of the most important engineering publications. It is distributed and used all over the world and the specifications and standard tests embodied in the Book and its Supplements have a tremendous influence on the purchase, production, and use of huge volumes of engineering materials.

ASTM Bulletin

DECEMBER 1948

NO. 155

NINETEEN-SIXTEEN RACE STREET
PHILADELPHIA 3, PENNA.

A.S.T.M. Is All Over[1]

THE new 1948 A.S.T.M. Year Book, just off press, has data indicating that truly A.S.T.M. is all over. Whether one is in Auckland, New Zealand, or Atzcapotzalco, Mexico, or Devil's Slide, Utah, or Boodepoort, South Africa, one will find members. Within the past few years, particularly, many new members have been received from across the seas. The current Year Book also is a repository of some very significant information, namely, the lists of personnel of the hundreds of A.S.T.M. technical committees. Probably no scientific or technical group in the world can show so many groups, and while there is no particular glory in numbers, the fact that almost all of these committees have extremely active programs under way in standardization and research in materials, is significant. The main technical groups have voting personnel ranging in number from twenty or so to several hundred and some groups have as many as 600 men active on various problems.

Some of the work has become so ramified that subcommittees and sections and task groups seem almost to be unending, but each is set up with a specific purpose and job. Some of the groups are so extensive that the advisory committees and the officers have real administrative problems confronting them almost constantly.

What makes this tremendous structure so significant is the fact that the thousands of technical men are serving *voluntarily* on these committees. This is a joint tribute—*first*, to the willingness and unselfishness of the men who contribute of their time and effort and knowledge, and *second*, it is likewise a recognition of the importance of the work, for those who are participating usually have many other important responsibilities and must concentrate their work on activities which are justifiable.

That which really ties together the very ramified A.S.T.M. activities in the final analysis is the wholehearted and splendid cooperation of our members and committee members.

[1] And we don't mean finished—far from.

Offers of Papers for 1949

THE Administrative Committee on Papers and Publications will meet early in February to consider the papers to be published by the Society in 1949 to develop the program of the 1949 Annual Meeting to be held in Atlantic City, N. J., June 27–July 1. All those who have in mind offering papers for presentation at the Annual Meeting and publication by the Society should send these offers to Society Headquarters no later than February 1.

All offers should be accompanied by a summary which should make clear the intended scope of the paper and indicate features that, in the opinion of the author, will justify its inclusion in the Annual Meeting program and publication by the Society. Suitable blanks to be used in transmitting the desired information will be sent promptly on request.

'49 Nominating Committee

IN ACCORDANCE with the By-laws, providing that the Board of Directors shall select a nominating committee for officers, the Board has considered the report of the tellers, J. J. Duffy, Jr., Assistant Manager of Sales, Pennsylvania Salt Manufacturing Co., and E. O. Hausmann, Director of Technical Control Dept., Continental-Diamond Fibre Co., on the recommendations of members for appointees on the nominating committee, and has selected the following committee and alternates:

NOMINATING COMMITTEE

Members

T. G. Stitt, Pittsburgh Steel Co.
R. N. Young, Lehigh Portland Cement Co.
Stanton Walker, National Sand and Gravel Assn.
A. G. Scroggie, E. I. du Pont de Nemours and Co., Inc.
H. S. Phelps, Philadelphia Electric Co.
W. C. Voss, Massachusetts Institute of Technology

Respective Alternates

P. R. Wray, Carnegie-Illinois Steel Corp.
W. C. Hanna, Calif. Portland Cement Co.
D. E. Parsons, National Bureau of Standards
H. J. Ball, Lowell Textile Institute
H. C. Miller, Public Service Electric and Gas Co.
K. B. Woods, Purdue University

The three immediate past-presidents, J. R. Townsend, Arthur W. Carpenter, and T. A. Boyd, serve as *ex-officio* members of the 1949 Nominating Committee. The committee will meet in March and make nominations for each office—President, Vice-President, and five Members of the Board of Directors. The selections by the nominating committee will be announced to the members in the ASTM BULLETIN prior to transmission of official ballots.

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
December 7	New York District Meeting	New York, N. Y.
December 16	Finance Committee Meeting	(A.S.T.M. Headquarters)
1949		
January 13	Philadelphia District Meeting	Franklin Institute, Philadelphia, Pa.
January 17–18	Board of Directors Meeting	(A.S.T.M. Headquarters)
January 24–26	Committee A-1 on Steel	Pittsburgh, Pa.
February 3	New York District Meeting	New York, N. Y.
February 10	Philadelphia District Meeting	Philadelphia, Pa.
March 22	Philadelphia District Meeting	Philadelphia, Pa.
April 5	New York District Meeting	New York, N. Y.
February 28–March 4	1949 Spring Meeting and A.S-T.M. Committee Week	Chicago, Ill.
June 27–July 1	1949 Annual Meeting	Atlantic City, N. J.
October 10–14	1949 West Coast Meeting	San Francisco, Calif.

Many Schools and Faculty Men Are Members of A.S.T.M.

Engineering Professors Play Important Part in Society Work

WHILE almost anyone might make the general assumption that a number of engineering schools and engineering professors would be affiliated with the Society, it is doubtful if any of us realize just how many schools and colleges in this country do hold membership. The accompanying table based on a recent survey of the membership lists the schools and indicates the number of individual memberships or other types held in the respective institutions.

The various schools and colleges enjoy the privilege of holding memberships through a department or a library or some other school division, and carry this on the basis of the individual dues.

This tabulation is presented now in part because the Society's Committee on Membership, headed by Everett G. Ham, is making a survey of the representation in the Society and has asked all of the A.S.T.M. members on engineering school faculties to suggest the names of their associates or friends at their own and other institutions who should benefit from personal affiliation with the Society. When these data are received the committee plans to contact the various professors and faculty members. Professor Frank Richart, University of Illinois, a past member of the A.S.T.M. Board and of the Membership Committee, is participating actively in this project.

The accompanying list should also be of interest to many of our members who would like to know about the total representation of their own schools in the Society. Should any member have any suggestions in connection with the activity of his school in A.S.T.M., the Membership Committee or Headquarters Staff would be glad to hear from him.

Society and Committee Officers from Engineering Schools:

It is not the purpose of this article to indicate how really widespread has been the participation of engineering professors in the Society nor to attempt to evaluate the important, constructive influence of these men on A.S.T.M. work. A general statement is in order that many engineering professors have participated very actively in the work and are now participating and doing a great deal to advance the Society's activities involving both standardization and research in materials. Beginning

Engineering School and College Membership in A.S.T.M.

School	Individual	Other[1]
Alabama College	1	0
Alabama Polytechnic Institute	0	1
Alabama, University of	1	2
Alaska, University of	0	1
Antioch College	0	1
Arizona University	0	1
Arkansas, University of	0	1
Brown University	1	0
Bucknell University	1	0
California Institute of Technology	2	1
California, University of	7	2
Canisius College	0	1
Carnegie Institute of Technology	1	1
Case Institute of Technology	3	0
Catholic University	0	1
Champlain College	1	0
Chattanooga, University of	0	1
Cincinnati, University of	0	2
Citadel, The	1	0
City College of New York	4	1
Clarkson College of Technology	0	1
Clemson Agricultural College	0	1
Colorado A and M College	0	1
Columbia University	3	1
Colorado, University of	0	1
Colorado School of Mines	0	1
Connecticut, University of	2	1
Cooper Union	1	0
Cornell University	6	1
Dartmouth College	1	0
Dayton, University of	1	0
Delaware, University of	1	1
Detroit Institute of Technology	1	0
Detroit, University of	0	1
Drexel Institute of Technology	2	0
Duke University	0	1
Fenn College	1	1
Florida, University of	2	1
Georgia Institute of Technology	2	1
Harvard University	2	0
Idaho, University of	1	0
Illinois Institute of Technology	2	1
Illinois, University of	25	0
Indiana University	0	1
Institute Paper Chemistry	0	1
Institute Textile Technology	0	1
Iowa State College	9	0
Johns Hopkins University	2	0
Kansas State—Agriculture and Applied Science	0	2
Kansas, University of	0	1
Kentucky, University of	1	1
Lafayette College	0	1
Lehigh University	2	1
Louisiana Polytechnic Institute	0	1
Louisiana State University	0	1
Louisville, University of	1	1
Lowell Textile Institute	2	0
Maine, University of	0	1
Manhattan College	1	1
Marietta College	1	0
Marquette University	1	1
Maryland, University of	1	1
Massachusetts Institute of Technology	21	1
Michigan State College	0	1
Michigan, University of	10	1
Minnesota, University of	3	3
Missouri, University of	0	2
Missouri School of Mines & Metallurgy	1	1
Montana School of Mines	0	1
Montana State College	0	1
Nebraska, University of	4	0
New Hampshire, University of	2	1
New London Jr. College	1	0
New Mexico College A. & M.	1	1
New Mexico, University of	2	1
New York State College of Ceramics	1	1
New York University	0	1
Notre Dame, University of	2	0
North Carolina State College	3	3
North Carolina, University of	0	1
North Dakota, University of	1	0
Northeastern University	2	1
Northwestern University	3	1
Ohio State University	6	2
Oklahoma A. & M.	1	1
Oklahoma, University of	1	1
Oregon State College	3	1
Pacific Lutheran College	1	0
Parks College of Aeronautical Technology	0	1
Pennsylvania State College	5	1
Pennsylvania, University of	1	0
Philadelphia Textile Institute	0	1
Pittsburgh, University of	0	1
Prairie View College	1	0
Princeton University	7	0
Purdue University	5	2
Queens College	1	0
Redlands, University of	0	1
Rensselaer Polytechnic Institute	6	1
Rhode Island State College	0	1
Rochester, University of	1	1
Rollins College	1	0
Rose Polytechnic Institute	1	0
Rutgers University	1	3
St. Joseph's College (Indiana)	1	0
Seattle College	1	0
South Dakota State College	1	1
Southern California, University of	0	2
South Dakota State School of Mines	0	1
South Carolina, University of	2	1
Stanford University	1	1
Stevens Institute of Technology	0	1
Syracuse University	3	1
Swarthmore College	0	1
Temple University	0	1
Tennessee, University of	1	1
Texas A. & M.	0	2
Texas, University of	0	1
Toledo, University of	2	0
Tufts College	0	2
Tulane University	0	1
Tulsa University	0	1
Union College	2	0
Utah, University of	1	1
Vanderbilt University	1	0
Virginia Military Institute	0	1
Virgnia Polytechnic Institute	1	1
Virginia, University of	0	1
Washington University (St. Louis)	2	1
Washington, University of	1	1
Wayne University	1	1
West Virginia University	2	0
Wisconsin, University of	5	1
Worcester Polytechnic Institute	0	1
Wyoming, University of	1	1
Yale University	5	1

[1] Library, College Department, etc.

with the very first Honorary Member listed in our records, he being Henry M. Howe, for many years Professor of Metallurgy at Columbia University, there are six Honorary Members whose primary professional activities involve the field of engineering education, and two of these men, Professors W. K. Hatt, of Purdue, and Thomas R. Lawson, of Rensselaer, are still with us. Indeed Professor Hatt is one of the three living members who have been in the Society for fifty years.

Likewise a review of the list of Past-Presidents of A.S.T.M. would indicate many faculty members in the list. Several of the Edgar Marburg Lecturers have been engineering professors, and the current list of officers of the A.S.T.M. technical committees, those groups which are really the heart of the Society, includes many men who are in the field of engineering education. Technical committees having officers (chairman or secretaries) affiliated with colleges and schools cover the following materials and subjects among others: lime, refractories, concrete and concrete aggregates, manufactured masonry units, structural sandwich constructions, whitewares, gaseous fuels, textile materials, soils, and spectrographic analysis.

One other fact may be of interest: apparently the school which has the longest record of continuous membership in the Society is Tufts College Engineering School, with the original date of membership 1904. Worcester Polytechnic Institute followed closely in '05; Cornell, Kansas, and the University of Melbourne (Australia) the following year, and Rensselaer Polytechnic Institute became affiliated in 1907.

It will be noted that the University of Illinois, with 25 individual memberships, leads the list, followed closely by Massachusetts Institute of Technology with 21 individuals and an institutional type membership; and the Universities of Michigan and California and Iowa State College are next in line, followed by Ohio State, Princeton, Purdue, and Rensselaer with a lesser number of memberships.

Finally the editors insert a "factor of safety" statement that while it is believed all of the schools in the United States and its possessions represented in the membership are listed, it is possible the survey may have missed some one or more institutions. We would be very glad to be reminded if any such omissions are noted; we believe the table is reasonably reliable but cannot guarantee its accuracy.

Credit Where Credit Is Due

Some of our readers who took occasion to check the statement on future publication policies which appeared in the October issue of the ASTM BULLETIN against the more extended account which appeared in the 1948 report of the Board of Directors may have wondered at the discrepancy between the two reports in reference to the special study committees that made the analysis on publications for the Administrative Committee on Papers and Publications. Specifically, the report as appended to the Board of Directors indicates that Dr. J. C. Geniesse was chairman of the committee that did the work on manner of publishing standards, which is correct; whereas the BULLETIN article indicates Mr. Gohn as chairman. Both Messrs. Gohn and Geniesse did a tremendous amount of work on this assignment but we wish to have the record straight. In addition to service with Dr. Geniesse on the standards problem, Mr. Gohn also served with Messrs. McVetty and Woods on the committee studying technical papers.

Membership Blanks Carry Onl (or) A.S.T.M. Books Are Not Like the One Hoss Shay—To Wit:

A GLANCE at the list of new members in this BULLETIN will reveal that Alfred Drew Collins, Chemist of the Dominion Lead Mills, Ltd., at Newmarket, Auckland, New Zealand, has joined the Society; and we are glad to welcome him into the growing list of technical people who are concerned with A.S.T.M. work in materials. We note his membership especially because the application for it came on a blank taken from the 1921 Book of Standards. Just how this came about we do not know and if Mr. Collins reads this note he may care to inform us, but it raises several points of interest: (1) the desirability of including (as we do) application blanks in some of the Society's bound publications other than the Year Book; (2) it indicates that even if the Books of Standards get pretty obsolete—and certainly the 1921 Book must be so considered—they still have something of value incorporated; and (3) to many of us this may perhaps create some thinking about the good old days when the Book of Standards, instead of being the present 7500-page volume in five parts (and in 1949 to be in six parts), was a relatively simple, one-part book covering 890 pages. It is of interest to note also that in 1921 the Society had a total of 160 standards; now there are almost 1500.

In Italy—A.S.T.M. Caps!

NONE other than the Secretary of The American Society of Mechanical Engineers, C. E. Davies, is the authority for the fact that in Italy they have A.S.T.M. Caps,—but we immediately implore our readers not to rush orders to us for these particular caps because an investigation of the matter indicates they refer to the automobile highway between Turin and Milan in Italy. Actually the symbols "A.S.T.M." represent "AOTO STRADA TORINO MILANO."

Early in October while riding from Turin to Milan, Mr. Davies was amazed to note the A.S.T.M. symbols on the caps of the workmen along the highway.

We are sorry that we cannot use these caps as evidence of the influence of the Society or how our promotional activities are getting across in Italy. However, we will promise to use pictures in the BULLETIN of any of these caps and wearers which may be sent to us by our members or others.

The only insignia which A.S.T.M. offers (at the members' expense, of course) are A.S.T.M. seals, or charms, or watch fobs, as noted in the current Year Book.

It is probably fortunate that A.S.T.M. does not issue letters and sweaters as do the high-school and college teams, because down through the years many hundreds of men would certainly have earned their letters on the basis of cooperation and work in the Society

Engineering Education?

The words "engineering education" are misleading. . . Why is not an engineer an educated man just as much as the physicist, the chemist, the historian, or the philosopher? We never label these men with "chemical education," "historical education," or other restrictive adjectives. . . . Why can the engineer not be considered an educated man? Engineering training can provide a liberal education once we establish our concepts as to its fundamental purpose. Certainly such concepts cannot be based on some particular curriculum to which all students must be subjected. The student never should be made to fit a mold. He should have opportunity to pursue studies outside of his major and he should be encouraged to do so. Standardization of courses and curricula may result in more uniformity in our graduates, but it is contrary to the principles of education. True education makes for inequality—the inequality of individuality, the inequality of success, the glorious inequality of talent and genius. For inequality, not mediocrity, individual superiority, not standardization, is a measure of the progress of the world.
—From October, 1948, *Electrical Engineering*, "Engineering Training—An Instrument of Progress," by A. G. Conrad, Chairman, Department of Electrical Engineering, Yale University, New Haven, Conn.

DISTRICT ACTIVITIES

Brief Notes on Recent and Future District Meetings

SEVERAL districts have scheduled meetings to be held during the winter months and to each of these, of course, are invited all members of the Society and their friends. Frequently the meeting announcements are sent to the members of other local chapters and sections in the respective area.

Weather and Man:

Pittsburgh held a meeting on Monday, November 29, at the Mellon Institute on the subject "Weather and Man, Particularly the Technical Man" with Dr. Hans H. Neuberger, Professor of Meteorology and Chief of the Division of Meteorology, Penn State College, State College, Pa., as the speaker. One of the country's outstanding authorities in the field, Dr. Neuberger has been at Penn State since 1937. He has written widely and is active in a number of scientific and technical societes concerning meteorology. During World War II he was engaged in special work for the United States Navy.

Smog Testing:

On Tuesday, November 30, at the Rodger Young Auditorium in Los Angeles, the Southern California District held a meeting on the subject of "Smog Testing" with Dr. Louis C. McCabe, Chief, Los Angeles Air Pollution Control District, as the speaker. Preceding his address there was a motion picture in color of smog conditions in the Los Angeles Area.

Clyde Williams on Research:

Dr. Clyde Williams, Director, Battelle Memorial Institute, and very active in the War Metallurgy Committee, World War II, is to speak on "research" at the meeting at Franklin Institute at Philadelphia on Thursday, January 13. He does not plan a "shotgun type" of address, but rather will concentrate on certain industrial aspects of importance, including the question of when to start and stop research or a specific topic allied to this.

This is to be a dinner meeting, and many of Philadelphia's leading industrialists and research executives will be invited to attend.

Quality Control:

On February 10, the Philadelphia District is planning an afternoon and evening session with a dinner intervening, featuring a down-to-earth discussion on quality control. There will be several papers relating to specific industries and the Johns-Manville film on quality control will be shown. Further announcement of this meeting will be made.

President Templin, New York:

On February 3, 1949, President Templin will speak at a meeting sponsored by the New York District in conjunction with the machine design group of the Metropolitan A.S.M.E. section. He will cover the subject of aluminum, but plans to discuss specifically problems that would be of interest to the machine design element in connection with aluminum. This meeting will be in the Engineering Societies Building.

Specifications and Quality Control at Joint T.A.P.P.I.-A.S.T.M. New England Meeting

Two related topics were discussed at the meeting sponsored jointly by the New England District of A.S.T.M., and the New England Section of the Technical Association of the Pulp and Paper Industry, on Friday, November 19, at Worcester, Mass. William R. Willets, In Charge, Paper Development Laboratory, Titanium Pigment Corp., and Lewis S. Reid, Assistant General Purchasing Agent, Metropolitan Life Insurance Co., covered The Philosophy of Specifications in a jointly written paper presented by Mr. Willets. Dr. George P. Wadsworth, Associate Professor of Mathematics, Massachusetts Institute of Technology, discussed Practical Quality Control in a stimulating way.

Since we are looking forward to publishing the prepared paper on Philosophy of Specifications, there is no attempt to abstract it here. Dr. Wadsworth's talk was of a nature that it would be difficult to describe without involving some of the mathematics which he used.

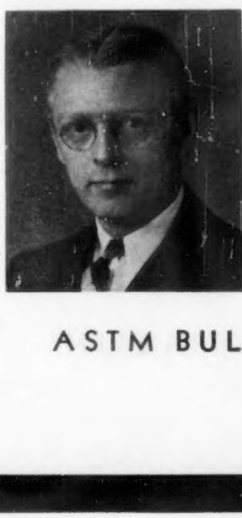
The interest in the subject was indicated by an attendance of close to 150, who, prior to the technical session, had dinner at the Sheraton Hotel.

Acting for both the T.A.P.P.I. and A.S.T.M. groups as program chairman was Randall H. Doughty, of the Fitchburg Paper Co. He presided at the dinner and session and was appropriately singled out for many complimentary remarks on the interesting affair. While the majority of the audience were from the paper industry, there was a goodly attendance, particularly of A.S.T.M. members from other fields including a number of the New England District Councilors. This was the first meeting under the new district officers, which include Chairman, V. J. Altieri; Secretary, Carlton G. Lutts; and Vice-chairman, Miles N. Clair.

Prior to the session, the New England Council met and decided that at the Spring Meeting subjects would be in the field of non-ferrous metals with probability of discussions on aluminum, magnesium, and titanium.

In addition to the officers of the local groups, the administrative "chiefs" of both societies were present: R. G. MacDonald, Secretary-Treasurer of T.A.P.P.I., and C. L. Warwick, Executive Secretary of A.S.T.M.

Following the presentation of the papers there was spirited and interesting discussion, the meeting finally breaking up about 10:30 o'clock.



← Lewis S. Reid

W. R. Willetts →

Good Design—On Purpose!, at Philadelphia Meeting

W. T. Bean, Jr.

About 150 members and their friends and associates, and members of certain other society chapters in the Philadelphia District, heard an excellent talk on the subject "Good Design—On Purpose!" at the District Meeting on October 13, at the Franklin Institute. The speaker was W. T. Bean, Jr., Research Engineer in Charge of Experimental Stress Analysis, Continental Aviation and Engineering Corp., Detroit. He concentrated on the theme—Good data + proper interpretation = good results. Through a series of slides he showed various case histories of how designs could and were improved when the stress concentrations and sufficient data were available. Most of his illustrations came from the famous Continental engines, but he had many different examples.

By the use of strain gages, Stresscoat, and such equipment and paraphernalia, he has been able to eliminate many weak spots in the engine and machine parts. The use of shot peening, nitriding and proper processing were cited as frequently desirable from the standpoint of good performance and economy.

By proper stress analysis, he has been able to increase the strength of many structures while eliminating unnecessary material, such as fins and certain types of fillets. He has also been able to eliminate certain types of failures by altering design to change a tension stress to a compression stress, etc.

He paid tribute to American industry and materials engineers for furnishing the designer with excellent materials. His thesis was not inferior materials but how to get the most out of the good materials we have. Good materials + good design + good processing, give the maximum performance.

Those who may wish to study some of Mr. Bean's techniques will find, if interested, his well-illustrated paper, part of the 1946 A.S.T.M. Symposium on Testing of Parts and Assemblies.

A. O. Shaefer, Philadelphia District Chairman, presided at the meeting, with the speaker introduced by the Technical Chairman F. G. Tatnall. Preceding the meeting, the Philadelphia Council and certain guests met at dinner and reviewed the progress in connection with the interesting meetings scheduled for the balance of the season.

President Templin Speaks at Several District Meetings

On invitation from several of the district councils, President Richard L. Templin has been the chief speaker at a number of interesting and successful meetings in the various localities. At each of these meetings he has, at the suggestion of the councils, discussed the subject of aluminum in which field he is an outstanding authority.

The first of these meetings took place on October 14 in Washington at the Wardman Park Hotel, this being the first session to be sponsored by the new Washington (D. C.) District. Next he attended the Chicago District meeting on October 19 at the new headquarters of the Western Society of Engineers; this meeting being a joint one with the W.S.E. Later he spoke in Philadelphia on November 10 at President's Night, and the most recent meeting was the Cleveland Meeting on November 16, at the Cleveland Engineering Society Building.

The Washington meeting was a joint one with Committee D-13 on Textiles Materials. Dr. Frederic Bonnet, formerly Director, Standards Department, American Viscose Corp., and now retired, although handling special assignments for the company, discussed the Five Outstanding Developments in Textiles During the Last Decade. This was a most interesting presentation and Dr. Bonnet's remarks are presented below.

Aluminum

Mr. Templin, who is Assistant Director of Research, and Chief Engineer of Tests, Aluminum Company of America, New Kensington, Pa., prepared his paper essentially as a broad thumb-nail sketch of this industry. Following brief historical notes, there was given a picture of the various forms which aluminum takes, that is, castings, wrought material and so forth, with statistics on fields of application and there were numerous illustrations of uses of this material in structural, architectural, domestic, and other fields.

One of the most interesting features of these meetings has been the informal discussion period which followed his address. He has been subjected to a barrage of questions, and with his vast knowledge of the field has been able, through the questions, to bring out very interesting points.

The Five Outstanding Developments in Textiles During the Last Decade—A Résumé[1]

By Frederic Bonnet[2]

The subject which has been assigned to me, namely, the Five Outstanding Developments in Textiles During the Last Decade, is based on the opinions of members of the Advisory Committee of A.S.T.M. Committee D-13 on Textile Materials, who were deemed, as stated by Professor Ball, the D-13 Chairman, to be a "sufficiently representative cross section of the industry for this purpose."

The response to our questionnaire, while not 100 per cent, was quite good and I wish to express my thanks to those members who took time to send in their letters to me but I was quite disappointed in not receiving a letter from our modest chairman himself, as to his choice. The opinions of several textile "experts" not members of the committee were also sent in to me at my suggestion and are included in the summary.

The replies were quite interesting and varied in that some listed many subjects, while others only two or three. Although there was, of course, a wide divergence in choice in some subjects there seemed to be quite a general agreement in regard to the first three.

The development of *the truly synthetic fiber*, *Nylon* ranked first as being

[1] Presented on October 14 at the Washington (D. C.) District Meeting, sponsored jointly by the District and Committee D-13 on Textile Materials.

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without question the most outstanding textile development during the past decade. The other types of synthetic fibers like Vinyon, Saran, Alginate, Protein, Orlan, Terylene, and even glass were usually mentioned in connection with Nylon, which stood at the top and seemed obviously to be considered as representative of the entire synthetic group of fibers.

The second choice and running a good second was *strong regenerated cellulose type of rayon*, the tire cord type, which also included one mention of the strong type derived from acetate rayon, namely Fortisan.

The third choice was *Resins* and their applications to textiles, which fall mainly under three heads:

1. As finishes to stabilize fabric construction, to give water repellency, crease resistance, etc.
2. Bonding of fibers in nonwoven fabrics
3. Strengthening paper and resulting paper yarns
4. As a vehicle for pigment coloring and printing of textiles.

Of these four the use for textile finishes is by far the most important. In this group we have included the well-known stabilization of rayon fabrics by the several glyoxal treatments rather than under a special heading of chemical modification. But since the glyoxal treatment stabilizes fabrics somewhat comparable to the formaldehyde and melamine resins, it was thought best to include them under resins. In the same way we have included pigment coloring under resins, rather than under dyeing and coloring of textiles.

The fourth choice seemed to fall to *mechanical developments* spread out, however, under about thirteen headings:

1. Long draft worsted spinning in cotton mills
2. Tow to top; or tow to yarn
3. Looms
4. High speed tricot or flat knitting machines
5. Automatic shuttle-bobbin winding
6. Electronic controls for the Bromwell feed
7. Mechanical cotton picking
8. Hot air slasher
9. Ring spinning replacing mule spinning
10. Continuous spinning of rayon
11. Continuous peroxide bleaching
12. Continuous and economic vat dyeing
13. Meta chrome dyeing for wool.

Under these thirteen headings, the high-speed flat knitting machines were mentioned most often in the replies; tied for second place under mechanical developments were:

(a) long draft worsted spinning in cotton mills
(b) high-speed circular and other looms
(c) continuous and economical vat dyeing

Continuous peroxide bleaching held third place.

Other subjects which might come under mechanical developments were the use of rayon cakes, and sanforizing of cotton goods.

The fifth choice seems to go to *Analysis and Analytical methods.* There were four references to analytical data correlating laboratory with service tests. The great importance of this was brought out so thoroughly during World War II by the large amount of work done and still being done by the various departments of our armed services, and it was surprising it did not rate a higher place.

The sixth place, as judged by the replies, goes to *research.* That is to say, the establishment of the various organized textile research agencies, of which the Textile Research Institute may be considered as representative.

Other subjects which were mentioned but which did not seem to fall into the above general categories were:

1. Chemical modification of wool to mothproof the fiber; to make it resistant to alkaline wash; to prevent shrinking and felting
2. Proofing of the cellulosic fibers toward weather, mildew, acid rotting, fire and water
3. Advances made in the blending of rayon, synthetic and natural fibers
4. Functional clothing
5. Water-soluble spinning lubricants
6. Use of colloidal silica as a spinning assistant
7. Self-scouring wool oils
8. Spun dyed rayon staple
9. Streamlining wet finishing process for wool by continuous piece scouring
10. Diesel power
11. Electric drive on textile machines
12. "Nymo"

The foregoing choice of textile developments represents merely more or less spot opinions. Possibly a much larger group and a more statistical minded correlator would have arrived at a different result, but in any case there is ample room for argument and discussion.

New York District Discusses Domestic House heating

At the meeting in New York City on October 26, jointly sponsored by the New York branches of the A.S.T.M., A.S.M.E., and A.S.H.V.E., three outstanding authorities in their respective fields discussed the Latest Developments in Domestic House Heating. The interest in the subject and the influence of the three societies was evidenced by a crowd of at least 450 which virtually filled the meeting room at the Engineering Societies Building.

Following brief introductory remarks by District Chairman Myron Park Davis, Carl F. Kayan, Professor of Mechanical Engineering, Columbia University, who served as Technical Chairman, introduced the three speakers.

H. H. Weber, Chief Engineer, Wire & Cable Dept., United States Rubber Co., covered Electric Panel Heating, which involves the use of so-called Uskon radiant home heating panels. This is a method of heating homes radiantly with a ceiling panel in which the source of heat energy is a layer of electrically conductive rubber. Following Mr. Weber was Peter B. Gordon, Treasurer, Wolff & Munier, Inc., who has done a great deal of work in the field of panel heating, specifically through circulation of hot water in

H. H. Weber

W. L. Knaus

Peter B. Gordon

various types and designs of piping. Essentially this system is a low temperature radiant heat application with the pipes located in various parts of the building, but usually in the floor panels because of easy installation. A large number of illustrations indicated the extensive use of this relatively new development, although some of the earlier installations have been in for a good many years. The final speaker was W. L. Knaus, Engineer, Air Conditioning Dept., General Electric Co., who discussed the use of the Heat Pump, covering some of the technical and economic problems associated with its application to residential air conditioning.

Milestones in Metals at St. Louis Meeting

UPWARDS of 165 members of the Society and their friends and members of the St. Louis Chapter of the American Society for Metals and the St. Louis Engineers Club, heard a most interesting address at the joint meeting ing in St. Louis on November 4 when Dr. Bruce W. Gonser, Supervisor of the Non-Ferrous Division of Battelle Memorial Institute, pinch-hitting for John D. Sullivan, the scheduled speaker, covered the topic Recent Milestones in Metals and Minerals. Because of illness in his immediate family, Mr. Sullivan could not be present, but had prepared a manuscript which was the basis of Dr. Gonser's talk. However, the speaker elaborated on various points in the paper and brought into play his comprehensive knowledge of many different fields.

Following the address, there was a rather extended question and answer period, and Dr. Gonser brought out some more interesting points. The speaker has been active in the A.S.T.M. technical committees for a number of years and is currently Chairman of Committee B-2 on Non-Ferrous Metals and Alloys.

Since it is hoped the address can be published or presented in the BULLETIN in extended abstract, no attempt is made here to cover the highlights of the paper.

Following the technical session of this joint meeting, the men present were guests of the St. Louis Engineers Club during a social period. All together, the meeting was a most interesting and successful one. Arrangements for the speaker and for A.S.T.M. participation were handled by District Chairman Dr. J. C. Hostetter, Mississippi Glass Co., and A.S.T.M. District Secretary John M. Wendling, City of St. Louis, Municipal Testing Lab. There was a good attendance of A.S.T.M. members, perhaps the record for distance travel going to R. S. Bradley, Director of Research, A. P. Green Fire Brick Co., Mexico, Mo. Mr. Bradley is very active in A.S.T.M. technical work, particularly Committee C-8, and has been closely associated with Mr. Sullivan in a number of activities.

For the Engineers' Club, greetings were extended by club Vice-President M. D. Dawson in the absence of the club President, Brice R. Smith. Walter E. Bryan, Secretary of the club, coordinated various details in excellent fashion.

Philadelphia to Have Two Session February Meeting on Quality Control

AN AFTERNOON and evening meeting with a dinner intervening is to be held in Philadelphia on Thursday, February 10, under the joint auspices of the A.S.T.M. Philadelphia District and the local section of the American Society for Quality Control. The meeting is to be held at McCallister's, 1811–17 Spring Garden St., which is just a few short blocks from A.S.T.M. Headquarters. In addition to an address at the dinner by a prominent industrialist there will be four speakers, two in the afternoon and two in the evening as follows:

Afternoon:

Organizing for Quality and Waste Control—Dr. Eugene H. MacNiece, Director of Quality Control, Johnson and Johnson, New Brunswick, N. J.

Study of Process Capabilities and Application at the Foreman's Level—Anthony Oladko, Foreman, Adhesive Plaster Mill, Johnson and Johnson, New Brunswick, N. J.

Dinner: 6:30 p.m.

Evening:

Mobilizing for Quality Control—Jos. N. Juran, formerly Chief of Inspection, Control Div., Western Electric Co.

Lecture and Training Film on Quality Control—Simon Collier, Director of Quality Control, Johns-Manville Corp., New York, N. Y.

The Chairman of the Program Committee is Herbert W. Stuart, Director of Quality Control, U. S. Pipe and Foundry Co., Burlington, N. J.

A cordial invitation to attend this joint meeting is extended to all interested. A number of organizations will receive further information by direct mail, as will all A.S.T.M. members and committee members in the Philadelphia District.

Automotive Antifreezes

PRACTICAL information on the essential properties and proper use of automotive antifreezes and cooling systems is given in the new booklet, *Automotive Antifreezes*, just issued by the National Bureau of Standards. This publication, although designed primarily for the average automobile owner, should prove helpful to manufacturers interested in entering the field of antifreeze production.

Included are the results of years of extensive tests at the Bureau as well as a summation of the work of other investigators. In addition to simulated and actual service tests of antifreezes, basic investigations of the physical and chemical properties of antifreeze compounds and of materials currently used in cooling systems were made. Answers are given to such practical questions as when to install an antifreeze, what strength to use, what kind of antifreeze is best suited to the service involved, how the automobile should be prepared for antifreeze, how to distinguish between different types of antifreezes, and when to replace an antifreeze. Pertinent physical properties and service performance of the major categories of antifreezes are also given.

NBS Circular 474, *Automotive Antifreezes*, consisting of 16 large two-column pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at a cost of 15 cents a copy.

TECHNICAL COMMITTEE NOTES

Work on Electrical Heating, Resistance, and Related Alloys

COMMITTEE B-4 on Electrical Heating, Resistance, and Related Alloys held a two-day meeting in Cambridge, Mass., on October 13 and 14 and many of the committee members, particularly those interested in contact materials, attended a Colloquium on Electrical Contacts which was held at the Massachusetts Institute of Technology.

At the meeting of Section A on Cathodes of Subcommittee VIII on Radio Tubes and Incandescent Lamps, J. T. Acker of the Western Electric Co. presented a summary report of the work of the section to date. This report also discussed the diode program and the test results that had been obtained by the committee. It was felt by all that this report was quite helpful in indicating the work still to be done.

Among other suggestions was a slight modification in the derivation of the Figure of Merit, now used to evaluate the various melts. It was agreed that the standard diode is satisfactory for comparing melts of the same alloy, but not adequate for the evaluation of minor changes in the experimental nickel melts that had been tested. Some changes in the diode construction were suggested and the proposed diode specifications reviewed. It was noted that nearly half of the sections for this tentative specification had been completed and the remaining sections were assigned to various members of the committee for further development.

The Data Committee of the Cathode Section presented a Proposed Recommended Practice for Cathode Melt Testing which, after discussion and minor revision, was approved for submission to the entire section. Three new cathode melts are now being tested. The Chemical and Metallurgical Committee of the Cathode Section reported considerable progress in the preparation of the Proposed Tentative Specifications for Nickel Cathode Sleeves for Electronic Devices. Progress was also reported on the standardization of emission mixtures and methods of application for them and also on electron diffraction studies of the interface.

Subcommittee IX on Methods of Test for Alloys in Controlled Atmospheres reported that the first tests had now been completed in the corrosion test furnace using 35–15 type samples. These tests are continuing.

Subcommittee X on Contact Materials also held a very well-attended meeting. There was lengthy discussion of the report on the tests that have been conducted by various members of the committee in connection with their study of the Surety of Making a Circuit. Progress was also reported on the Proposed Tentative Method of Test for Determining Hardness of Contact Materials which, it is indicated, will be completed during the current year. The Section on Standardization of Contact Forms and Sizes reported that some difficulties were being experienced in securing the proper availability of all the sizes they had tabulated and this matter is being looked into further with the view of making some revisions in the proposed standard dimensions. The new Section on Micro Current Contacts reviewed their assignment and laid out the program of work which they are undertaking.

After the Subcommittee X meetings the members adjourned to the Massachusetts Institute of Technology where, on the afternoon of October 14 and all day October 15, a Colloquium on Electrical Contacts was conducted with Dr. L. H. Germer of the Bell Telephone Laboratories presiding. Seven papers were presented and proved very interesting to the subcommittee and provocative of extensive discussion.

Subsequent to the meeting in Cambridge the Advisory Committee of the Cathode Section met in Newark, N. J. on November 16 to further review the Cathode Section's program development. At this meeting it was decided that the diode program should be modified to include performance characteristics of cathodes in addition to purely emissive characteristics. Also, since the structure of the diode may be modified, such a tool should probably be renamed a "measurement tube." The Advisory Committee also took steps looking to the coordination of the work of the A.S.T.M. Committee with that of the Armed Forces' Panel on Electron Tubes, and outlined various suggestions for a research type of program they felt should be undertaken.

Activities on Copper and Copper Alloys Cast and Wrought

Committee B-5 on Copper and Copper Alloys, Cast and Wrought and all of its subcommittees dealing with the wrought products held a three-day meeting at A.S.T.M. Headquarters in Philadelphia on November 3, 4, and 5. Chairman G. H. Harnden of the General Electric Co. presided at the meeting of the main committee on the 5th.

The committee voted to apply the type designations for copper contained in the new Tentative Classification of Coppers (B 224) to its copper specifications. The committee also voted to make a number of changes in dimensional tolerances in its specifications for wrought alloys and add notes regarding the significance of the numerical values in its specifications and to apply the rounding off procedure to follow the Recommended Practices for Designating significant places in specified limiting values (E 29). The committee also voted to use in its wrought specifications an appropriate reference to the Standard Method of Sampling of the Non-Ferrous Metals and Alloys (E 55), effectuating an agreement reached with Committee E-3 through a small joint task group.

The Subcommittee on Plate, Sheet and Strip voted to add requirements for a third grade of aluminum bronze designated Alloy D to the Specification for Aluminum Bronze Plate, Sheet and Strip (B 169). This will be a nominal 90 per cent copper, 7 per cent aluminum, 3 per cent iron alloy, suitable for boiler plate.

The Subcommittee on Rods, Bars and Shapes voted to adopt the report of its Task Group on the Tension Testing of Rod and Bar Stock which provides for setting up elongation values in its specifications on a basis of four times the diameter rather than in a uniform 2-in. gage length with the testing to be done in accordance with the Tentative Methods of Tension Testing of Copper and Copper-Alloy Rods, Bars and Shapes (B 220). The subcommittee also voted to make minor changes in several of its other specifications.

The Subcommittee on Pipe and Tube

voted to raise the weight tolerance for individual tubes in the Specifications for Copper Water Tube (B 88) from 5 per cent to 7 per cent. The subcommittee also voted to make some minor changes in the Table of Chemical Requirements in the Specifications for Copper and Copper Alloy Seamless Condenser Tubes and Ferrule Stock (B 111) and to add tables of preferred size of tubing as appendices to the Specifications for Copper Tubes (B 75) and Brass Tubes (B 135).

The Subcommittee on Methods of Test reported that task groups were still working on the Proposed Method for Tension Testing of Thin Sheet Metal, on the effect of speed of testing and on studying the relation between Rockwell hardness and thickness.

The Editorial and Publications Subcommittee considered the problem of proposing a standard form for the committee's specifications and made recommendations to the other subcommittees regarding the number of significant figures to be used in the tables of chemical composition and on minor changes in a number of the specifications to bring the chemical requirements for the same basic alloy into agreement, in so far as possible, regardless of the form of the material.

Group Meetings of Four Constructional Material Committees

For the third time in the past two years, certain committees in the constructional materials field with overlapping membership arranged successive meetings which proved very successful in attendance as well as in the conservation of time required. Committees C-1 on Cement, C-7 on Lime, C-9 on Concrete and Concrete Aggregates, and D-4 on Road and Paving Materials met at the Hotel Jefferson in St. Louis, Mo., during the period October 26 to 29, inclusive. The combined schedule of meetings was arranged by Society Headquarters. In addition, the Materials Committee of the American Association of State Highway Officials met on October 25 and 26, of which more than 50 per cent of the membership were members of the A.S.T.M. committees. The total schedule included 50 committee and subcommittee meetings over the four-day period.

Cement

Committee C-1 on Cement held its meeting on the morning of October 29 with nine subcommittees meeting on October 27 and 28. The majority of the subcommittee reports presented were in the nature of progress reports. Included in action taken was a recommendation for further revision of the A.S.T.M specification covering portland cement (C 150). The proposed revisions include a change in the chemical requirements for Type V cement to relieve the somewhat restrictive effect of an Al_2O_3 limit of 4 per cent by dropping the Fe_2O_3 and the Al_2O_3 limits and adding the requirement that the C_3A shall not exceed 5 per cent and the C_4AF plus twice the C_3A content shall not exceed 20 per cent. A tentative method of penetration test for determining the time of setting of cement in mortar was accepted for letter ballot, this being a revision of the proposed method published as information only as an appendix to the 1948 Annual Report. A tentative specification for the 10-in. flow table including design was also approved for committee letter ballot. A revision of the Specification for Masonry Cement (C 91–48) was accepted to provide for two types of masonry cement, namely, Type I for use in general purpose masonry; Type II for use where high strength is required. The required strengths for 2-in. cubes, made, stored, and tested in accordance with C 91 requirements, shall be not less than the following: For Type I, 250 psi. at seven days, 500 psi. at 28 days; for Type II, 500 psi. at seven days, 1000 psi. at 28 days.

The Working Committee on Fineness proposed wider tolerances in the air permeability apparatus to allow acceptance of apparatus now being manufactured and called attention to a rather serious problem in connection with the turbidimeter apparatus in that certain types of this apparatus are being manufactured and sold in quantity which do not meet the A.S.T.M. specifications. Two further items reported on were: (1) an outline in tentative form has been prepared covering test methods for evaluating additions to cement and (2) study is to be given to the comparison of the results obtained from the use of the flow table and the flow trough for the purpose of establishing the possibility of the elimination of the flow trough and thereby having only one method for determining consistency of mortar and concrete.

Lime

Committee C-7 met on October 26 with four subcommittees preceding the main meeting. Several new memberships were reported representing the chemical limestone field in line with the expanded scope of the committee. Letter ballot has now been completed covering the recommendations for adoption of the tentative specifications on normal and special finishing hydrated lime (C 6 and C 206), tentative specification for hydrated lime for masonry purposes (C 207), and tentative method of physical testing of quick lime and hydrated lime (C 110).

Reports of subcommittees noted the following items: changes are felt desirable in the current slaking requirements for structural lime; attention will be given to the advisability of adding grit to hydrated finishing limes to improve workability; and round-robin laboratory tests will be continued on such tests as settling, SiO_2 content, fluorine content, CO_2 absorption trains, autoclave, and etc. A review of the research work on lime being conducted at the Massachusetts Institute of Technology was made by Chairman Murray of the research subcommittee. The next meeting of Committee C-7 will be in connection with the Annual Meeting of the Society in Atlantic City in 1949.

Concrete and Concrete Aggregates

Forty-six members of Committee C-9 on Concrete and Concrete Aggregates attended the main meeting on the afternoon of October 29 in addition to 30 visitors. Items of interest reported on by several of the subcommittees included the new proposed definitions of the term "mineral aggregates" which will be circulated to the committee for information and eventually to Committee E-8 of the Society; new methods are being prepared as a revision to the method of test for volume change of cement mortar and concrete (C 157) to consist of two parts, one describing test apparatus and procedure and the other describing the conditions under which shortage due to prolonged drying should be determined; the proposed method of test for air in concrete using the pressure principle has been completed for circulation to the committee; and revisions were approved to specifications for concrete aggregates (C 33) which will bring it in accord with the recently adopted Simplified Practice Recommendation for Sizes of Coarse Aggregate (R 163–48) as well as closer agreement with the corresponding AASHO specification.

It is expected that a revised method for evaluating air-entraining admixtures, published in October, 1947, Bulletin, will be adopted this year. A proposed test method for bleeding of concrete is being submitted to commit-

tee ballot for adoption as a new tentative method. Another new development has been the preparation of a method of test for bond of concrete. This method is not applicable for studying such things as characteristics of steel bars. A proposed method of test for soft particles in coarse aggregate is in preparation.

The chairman and secretary were authorized to fix the time and place of the next meeting. The committee voted to hold its 1949 fall meeting in San Francisco in connection with other committees of the Society.

Road and Paving Materials

Forty-three members were present at the main meeting of Committee D-4 on Road and Paving Materials held on the afternoon of October 28 with an additional number of visitors. The committee was very well represented in the number of subcommittees holding meetings totaling 18.

Included in the many phases of committee activity reported on were the following items: a tentative method of test on the effect of water on compressed bituminous mixtures is being resubmitted to subcommittee for further review; a revised list of terms was recommended for submission to the Society from which were excluded the terms "petroleum flux" and "dehydrated tar"; cooperative tests are to be undertaken to establish a proposed method for the destruction and recovery of bitumen by the Rotarex method with samples being taken from a road job; changes in the float test will be circulated for subcommittee ballot; a standard procedure for the Engler viscosimeter will be formulated and circulated for comment; a tentative revision in the Los Angeles abrasion test was recommended for committee ballot which will extend the scope of the test to include coarser sizes; further revisions were proposed in the recently adopted tentative method for sampling bituminous paving mixtures (D 979); and cooperative work is to be continued in the use of the glass plate test for use in developing the effect of stripping action of bituminous coated aggregates.

Further items include a revision of the specifications for asphalt cement (B 946) to be circulated to the subcommittee which deals with the addition to the scope of a statement covering uniformity coefficients; an additional grade of emulsion will be proposed for inclusion in the tentative specifications for asphalt emulsions (D 977) covering a grade heavier than now used for surface treatment; the specification for crushed stone and crushed slag and gravel for water-bound courses (D 694) will be reviewed for revision which will change the gradings to conform to the latest revision of the Simplified Practice Code; a specification is to be prepared covering mineral-filled asphalt joint sealing compounds of the hot-poured type; and study is continuing in the review of the two softening point test methods (D 36 and E 28) with particular attention to the mechanical stirring section.

Announcement was made of the election to honorary membership in Committee D-4 of Prevost Hubbard, secretary of the committee from 1908 to 1946.

Fall Meeting of Committee C-8 on Refractories

Committee C-8 on Refractories held its fall meeting on September 9 at Conneaut Lake Park, Pa., in connection with the meeting of the Refractories Division of the American Ceramic Society. This was the 74th meeting of Committee C-8 since its organization in 1914. In the various subcommittee reports several items of interest were noted.

Industrial surveys on refractory service conditions are being conducted for revision of the existing reports in the lead, copper, and malleable iron industries. In the Subcommittee on Tests, the problem of establishing a suitable furnace for the pyrometric cone test is receiving attention. Cooperative work is proceeding on a comparison of the differences in reheat behavior between the present test (C 113) and a panel test. Revisions are being considered in A.S.T.M. Standard Method of Test for Workability Index of Fireclay Plastic Refractories (C 181) and in the Tentative Specification for Castable Refractories for Boiler Furnaces and Incinerators (C 213 T), the latter being in particular reference to the reheat change test and the temperatures used in this test.

The new Section on Disintegration by Carbon Monoxide has inaugurated work which initially will be concerned with the collection of a complete bibliography on the effect of carbon monoxide on refractories, questionnaires to establish what work has been done on the subject, and the study of chemical and thermal dynamic aspects of the test.

The Subcommittee on Heat Transfer has been active on two items, namely, (1) analysis of the general suitability of our present standard methods for thermal conductivity, and (2) the inadequacy of the present standards in covering the testing of materials where the conductivity does not maintain a constant value after customary runs. It has been suggested that electrical conductivity tests be included in the work of this subcommittee.

Committee C-16 on Thermal Insulating Materials Adopts Reorganization Plan

An important action at the recent meeting of Committee C-16 on Thermal Insulating Materials was the final approval of the revised by-laws whereby reorganization of the committee structure was effected. The meeting was held at Haddon Hall, Atlantic City, on October 11 and 12. The committee will now operate on the basis of three groups of subcommittees, namely, administrative, thermal properties, and nonthermal properties. The administrative group will include a planning subcommittee composed of the subcommittee chairmen of all working subcommittees and representatives of other interested or allied societies. Research will be an important responsibility of this subcommittee.

The status of several proposed standards was discussed. In the field of block and pipe insulation new methods for determination of density of block insulation and for pipe insulation are being considered and a method for determining the water absorption of block insulation is being prepared for letter ballot. Specifications on block insulation products are being studied to determine the specific properties on which limitations should be set up.

Four methods for measuring adhesion-after-drying of thermal insulating cements are being studied. Further study is also being given to compression-shear factors in insulating cements as well as the plasticity of wet-insulating cement.

The subcommittee on blanket insulation is reviewing test methods to cover additional properties needed to be measured, including weathering, resiliency, and fire resistance. Decision was reached to include the term "bat" with the term "blanket" as being synonymous with the same general type of insulating material.

A method for measuring density of loose-fill insulation is being reviewed by the appropriate subcommittee. This subcommittee is also interested in studying properties of loose fill materials other than thermal insulating value.

A proposed method for measuring thermal conductivity by use of the

guarded hot box method has been reviewed preliminary to subcommittee ballot and a method for pipe insulation also is being written. The guarded hot box method is a companion method to the existing standard method for measuring thermal conductivity by means of the guarded hot plate (C 177), to be used for composite materials whereas the guarded hot plate is used for basic materials only. The subcommittee on special thermal properties reported on round-robin tests being conducted on specific heat data and on a study of certain permanence characteristics of thermal insulations such as the effect of moisture at all temperature ranges and on all insulation. It was felt that emissivity is a property that should be considered.

In studying dimensional standards, the subcommittee on this subject presented a preliminary report on the determination of clearance between pipe and insulation. Consideration of the use of a gage to determine the size of clearances between pipe covering and insulation will be given in preparing a table on these clearances. Revisions in the tentative method of test for water vapor permeability of sheet materials (C 214 T) are being considered such as the enlargement of the scope to include all vapor barriers and consideration of thicker samples.

Structural Sandwich Construction Committee Will Emphasize Simulated Service Testing

PERMANENT officers were elected at a two-day meeting of Committee C-19 on Structural Sandwich Constructions, held at ASTM Headquarters on November 18 and 19. Professor A. G. H. Dietz, Massachusetts Institute of Technology, D. G. Reid, Chance-Vought Aircraft Div., and E. C. Hartman, Aluminum Company of America, were elected as permanent chairman, vice-chairman, and secretary, respectively, each having held these positions on a temporary basis. F. G. Tatnall, Baldwin Locomotive Works, was elected to fill a vacancy as member-at-large of the Advisory Subcommittee, the other two members being L. J. Markwardt and R. B. Crepps. It was announced that the By-laws of the committee have now been accepted by proper letter ballot.

Interesting discussions took place at the four subcommittee meetings held in the consideration of the work that should be undertaken in the field of sandwich constructions. Subcommittee I on Mechanical Properties of Basic Materials reviewed the list of core materials which had been grouped according to type, and decision was made to confine further discussion to the main groups rather than to individual items, considering test methods applicable to each group. Dimensional stability was added to the list of properties that are considered of importance in the field of core materials. Three sections are planned for further organization within the subcommittee to deal with mechanical, physical, and electrical properties, respectively. The differentiation between mechanical and physical properties will be in that mechanical properties include those involving stress and requiring the use of testing machines. The term "bondability" was agreed upon for use in describing the property of a core material to adhere to other materials.

Subcommittee II on Mechanical Properties of Basic Sandwich Constructions reviewed a proposed method to measure tension-flatwise to be sent to subcommittee letter ballot. Methods covering compression, both edgewise and flatwise, and flexure as used by the U. S. Forest Products Laboratory were reviewed with discussion on size of specimen being the major item.

It was recognized that a most important field of endeavor of Committee C-19 is that of permanence, durability, and simulated service testing. Subcommittee III covering this field has inaugurated some preliminary work, one phase being a survey of suggested tests on sandwich construction as required in the building field. The Section on Exposure Facilities will continue to be in contact with the activities of the Advisory Committee on Corrosion of the Society and will rely on the other working subcommittees to specify size and number of specimens that should be required for outdoor exposure tests. The Subcommittee IV on Nomenclature and Definitions reviewed a list of definitions pertaining to structural sandwich constructions eliminating all terms which are of a general nature and apply to other than sandwich construction. Other terms were eliminated which were of a generic nature. A revised list will be circulated to the subcommittee for letter ballot. The next meeting of the committee will be in Chicago in conjunction with the Spring meeting of the Society.

Inspection Trip Features Meeting of Committee D-10 on Shipping Containers

Two items of interest in connection with the meetings of Committee D-10 were a talk given by A. B. Perry, Chief Field Engineer, Signode Steel Strapping Co., who spoke on the subject "The Function of a Test Track in Developing Good Packaging and Carloading Methods" and an inspection trip through the new laboratories of the General Box Co. in Chicago. The members were afforded the opportunity of seeing one of the most modern and completely equipped laboratories for the testing of shipping containers, principally of the wooden crate and box type. The committee met at the Hotel Bismarck, Chicago, on October 7 and 8. Well-attended subcommittee meetings were held on October 7 followed by a meeting of the main committee on October 8.

The Subcommittee on Tests, through its several sections, reported extensive activity, including the development of a test method for large crates and shipping cases and a drop test for bags. Discussion took place on the need for a method of measuring puncture of containers as compared with a snagging test, with further study to be given to this matter. Uncertainty was expressed on requirements for a hydrostatic test for metal cylinder containers and further inquiry will be made in view of existing coverage by The Bureau of Explosives of the A.A.R. The need was expressed for a torsional test for containers weighing under 1000 lb., including contents. Due consideration was given to criticism on the recommended test for penetration of liquids into submerged containers following which resubmittal to the Society was approved.

The Subcommittee on Performance Standards reported progress in its difficult task of establishing performance requirements. An important step has been taken by the subcommittee in classifying articles being shipped according to shipping carriers. Four classes of shipping carriers were established on the basis of the ease of shipment. Classification (*a*) includes carload shipments (being the easiest); class (*b*) includes air, mixed and pool carloads, L.C.L.,

L.T.L., mail and express; class (c) commercial export; and class (d) military export.

The Subcommittee on Interior Packing submitted an extensive list of definitions which will be turned over to the Subcommittee on Definitions for review preliminary to letter ballot of the entire committee. The subcommittee believes that existing test methods formulated by Committee D-10 are adequate for use in testing interior packing.

It was announced that the Spring Meeting of D-10 will be held at Atlantic City on May 9 and 10 in connection with the meeting of the American Management Association.

Various Phases of Adhesives Testing Discussed

MUCH was accomplished at recent meetings of Committee D-14 on Adhesives held in Washington, D. C., November 10 to 12, inclusive. All subcommittees held meetings which were well attended by both subcommittee members as well as the general committee membership. A few of the developments discussed and reported on are noted. The Subcommittee on Tests for Working Qualities reported on a proposed method for measuring the storage life of various adhesives which is being referred to the section for revision with the suggestion that a strength test be included. The Subcommittee on Permanence reported that a proposed test method on the effect of continuous exposure to heat and moisture has been sent to ballot in the subcommittee. Cooperative cycling tests are to be repeated on wood bonds with additional tests to include metal-to-metal bonds. A proposed method on the effect of chemical factors has been revised preliminary to submittal to committee ballot.

The recently authorized subcommittee on electrical properties of adhesives has now completed its organization which will consist of four sections dealing with dielectric strength, insulation resistance, dielectric constant, and power factor and arc resistance, respectively. These sections will study proposed methods of testing these respective properties. Two of the problems which will be studied by the research subcommittee will be corrosion of adhesives and permanence with attention on the latter being given to the difficult problem of setting up an accelerated test. In addition, the fundamental approach to the question of adhesion and the origination of test specimens to measure pure stress will be before this subcommittee.

The specifications subcommittee is proceeding with the formulation of a tentative specification which initially will be modeled after an existing A.S.T.-M. specification covering rubber and synthetic rubber compounds (D 735T). It was felt that two types of permanence tests should be included in the properties required in such a specification. The draft of this specification will be circulated to the entire committee for comments. Decision was reached to hold the next meeting of the committee in Chicago during the first week of April, 1949.

Over 100 at 10th Anniversary Meeting of Committee D-20 on Plastics; Much Work Under Way

COMMITTEE D-20 on Plastics met in Atlantic City on November 16 and 17 with an attendance of 110 members and guests. Meetings were held of all of its 12 subcommittees. The meeting included a banquet commemorating the tenth anniversary of the organization of Committee D-20.

On the recommendation of the Subcommittee on Strength, Committee D-20 took action to present to the Administrative Committee on Standards a new tentative method of test for tear resistance of plastic film and a tentative method of test for tensile properties of thin plastic sheets and films which latter is a revision of A.S.T.M. Method D 882. Both of these methods were prepared in cooperation with the Society of the Plastics Industry. Changes were made in both methods following consideration of criticisms received in a committee letter ballot on the methods.

A new method of test for stiffness *versus* temperature properties of nonrigid plastics by means of a torsional test was approved for submission to letter ballot of the Subcommittee on Strength. This method covers a procedure for determining stiffness characteristics of nonrigid plastics over a wide temperature range.

Action was taken on revision in the Tentative Method of Test for Flexural Properties of Plastics (D 790 – 45 T) to cover the testing of thin sheet materials ⅛ in. and under. These revisions are being made as the result of certain research work at the Johns Hopkins University and the University of Delaware.

The Subcommittee on Optical Properties is undertaking a study of a method for the measurement of the gloss of thin plastic films using a recording goniophotometer. This work when completed will result in a revision of the Method of Test for Diffusion of Light by Plastics (D 636 – 43).

The Subcommitttee on Permanence submitted for letter ballot of Committee D-20 a new tentative method of test for determining shrinkage of plastics from linear dimensions.

The Subcommittee on Specifications presented revisions in the Tentative Specifications for Polystyrene Molding Compounds (D 703), and for Laminated Thermosetting Materials (D 709). It also recommended the adoption as standard of four Tentative Specifications covering Cellulose Nitrate Plastic Sheets, Rods and Tubes (D 701), Vinylidene Chloride Molding Compounds (D 729), Ethyl Cellulose Molding Compounds (D 787), and Cast Allyl Plastic Sheet, Rods, Tubes, and Shapes (D 819).

The Subcommittee on Analytical Methods has been actively studying procedures for the analysis of plasticizers, including tests for acidity, saponification, specific gravity, color, and stability. Work is also under way on methods for determination of plasticizer, residual solvent, pigment, and filler in cellulose ester plastics.

The adoption as standard of the Tentative Method of Test for Acetyl and Butyryl Content of Cellulose Acetate Butyrate (D 817), and for Short-Time Stability at Elevated Temperatures of Plastics Containing Chlorine (D 793) was recommended.

The Subcommittee on Molds and Molding Processes presented four recommendations. The first was a procedure for molding water absorption specimens; the second a transfer mold for inclusion in D 647 which covers molds for test specimens of electrical insulating materials; the third a recommended practice for phenolic transfer molding; and the fourth a revision of D 647 to cover an injection mold.

A code for describing the direction of testing when reporting test values of plastics was approved for submission as tentative to the committee on standards. The following four definitions were also approved for publication as tentative: Thermoplastic (adjective), Thermoplastic (noun), Thermoset (noun), and Thermosetting (adjective).

At a very interesting session arranged by the Subcommittee on Research the following four papers were presented:

Ignition Temperatures of Plastic Materials—Mr. Lamb, of the National Bureau of Standards

Proposed Test for the Weight Loss of Plastics on Heating—Mr. M. E. Marks, Columbia Chemical Div., Pittsburgh Plate Glass Co.

Impact Behavior of Thermoplastics and Laminates—Mr. H. M. Quackenbos, Jr., of the Bakelite Corporation, and

Some Notes on the Effect of Testing Machines on the Tensile Properties of Plastic Films—L. Boor, of the Office of the Quartermaster General

The meeting was concluded by a showing of a sound color film, furnished through the courtesy of the Society of the Plastics Industry, which illustrated the work conducted at the Massachusetts Institute of Technology.

Changes Contemplated in Thermometer Specifications in 1949

THE Standard and Tentative Specifications for A.S.T.M. Thermometers (E 1–47 and E 1–47 T) cover etched stem glass thermometers graduated in Centigrade and Fahrenheit degrees. These specifications cover a total of 58 different thermometers which are specified for use in a number of A.S.T.M. methods of test.

Some of these specifications were originally included in detail in the A.S.T.M. Methods before the E-1 Thermometer Specifications were compiled in tabular form in 1939; others have been added from time to time to meet new requirements for temperature measuring instruments in A.S.T.M. methods.

The older specifications were in most cases accepted as E-1 Standards in their original form, but as new thermometers were added certain refinements were incorporated in the specifications to bring them in line with the latest manufacturing and standardizing practices.

It is obvious that minor differences between the earlier and later specifications would develop. Some of these differences were reconciled by making editorial changes. Others have been of sufficient importance to be referred for approval to the A.S.T.M. technical committees concerned.

About three years ago Section A on Thermometers, of Committee E-1 on Methods of Testing, recognized that a thorough investigation of inconsistencies which had not been corrected was desirable, and a special subcommittee was appointed to make this study and to submit recommendations to Section A.

This special subcommittee was authorized to investigate those inconsistencies which could be made without disturbing the basic characteristics of the thermometers. Later it would review revisions in specifications which might require action of the technical committees involved, such as changes in the accuracy or dimensional requirements.

After a thorough study and discussion of the specifications at several meetings, the Section on Thermometers has now approved a number of revisions which will involve changes of the following nature:

1. Adding graduations below the 0 C. (32 F.) mark to conform to the National Bureau of Standards requirements for certification.
2. Adoption of a uniform system of terminal numbering to prevent errors in reading.
3. Graduations below 0 C. or 0 F. marked in a prescribed manner to differentiate them from the scale above zero.
4. The A.S.T.M. thermometer number to be etched on the tube along with the name of the thermometer.
5. Abbreviations of the A.S.T.M. test names, shortened in some cases.
6. A more uniform method of specifying expansion chambers.
7. Contraction chambers more definitely specified as to location and shape.
8. Permission given to use "contrasting colors" rather than red in certain cases where specific test temperatures are to be in a different color than the main body of graduations and numbers.

It is planned to have the above changes incorporated in the thermometer specifications in 1949. The committee wishes to make it clear, however, that these changes in the specifications do not affect the basic characteristics of the thermometers in so far as temperature measurements are concerned. Thermometers which have been manufactured in accordance with the present specifications should definitely retain the same official status as those in which these revisions will be incorporated.

Other changes in the interest of uniformity and clarity are of an editorial nature and will be included in the standards next year. These include a new tabular arrangement for the specifications, the elimination of many footnotes, and the rewriting of certain paragraphs in the general text of the specifications.

The special subcommittee appointed to review and to suggest corrections of the inconsistencies in A.S.T.M. thermometer specifications will continue its work and will concentrate on bringing into conformity the Centigrade and Fahrenheit ranges of certain thermometers so that the manufacturers can use the same blanks for either range of a given item.

Scope of Committee E-7 to Cover Nondestructive Testing

A RECENT announcement has been made of the extension of the scope of A.S.T.M. Committee E-7 which formerly was confined to radiographic testing, the expansion to cover nondestructive testing in general. Since Committee E-7 is anxious to have a very broad representation to cover both the practical and theoretical point of view, the officers of all technical committees have been asked to determine the interest of their groups and whether representation on Committee E-7 is desired.

Committee E-7 has been very active for many years in stimulating an interest in radiographic testing; it has sponsored two very valuable symposiums which have been heralded widely as outstanding books, and it is believed that with the expansion of the scope to cover nondestructive testing the committee can make a number of very valuable contributions to this field.

The announcement indicates that the expanded scope would envisage the type of test for use in detecting discontinu-

ities or structural irregularities in engineering materials. These tests include magnetic powder, radiographic, ultrasonic, and other methods of a similar nature. In undertaking this new assignment, the committee will devote its attentions to the development of general test procedures, but it will assume no responsibility for product specifications. The individual technical committees, responsible for the development of product specifications, may also be interested in developing special test procedures, and in such instances Committee E-7 will be prepared to serve in an advisory or consulting capacity.

J. H. Bly, Materials Control Laboratory, Pratt & Whitney Aircraft Division, United Aircraft Corp., East Hartford 8, Conn., is the chairman of the committee and the secretary is D. T. O'Connor, Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md.

Joint Committee on Chemical Analysis by X-Ray Diffraction Expands

Second Supplementary Set of Cards Soon to Be Issued

THE Joint Committee on Chemical Analysis by X-Ray Diffraction Methods, sponsored by the American Society of X-Ray and Electron Diffraction, the (British) Institute of Physics, and the A.S.T.M., has recently enlarged its membership to include representatives of A.S.T.M. Committees which have indicated an interest in the Joint Committee's work. This is in recognition of the very widespread application of X-Ray diffraction and in the interest of building up the index.

In 1941 the A.S.T.M. published for this committee an original set of 4000 cards for identifying crystalline materials by X-ray diffraction, and in 1944 a supplementary set of 4500 additional cards. These two sets have become universally known as the Card Index File for Identification of Crystalline Materials by the Hanawalt X-Ray Diffraction Method. An additional supplementary set of approximately 1500 cards has been under preparation for nearly two years and will shortly be issued. Diffraction, physical and chemical data have been rearranged on new cards to include fuller information. The committee is considering printing this second supplementary set on Keysort cards and then reissuing the original and first supplementary set on the same type of card. Preparation of the original and the two supplementary sets of data has been carried on at the Pennsylvania State College by Dr. W. P. Davey, Research Professor of Chemistry and Physics.

The new members of the Joint Committee are as follows:

R. F. Blanks, U. S. Bureau of Reclamation, representing A.S.T.M. Committee D-18 on Soils for Engineering Purposes.

H. A. Heiligman, Lavino Refractories Co., representing A.S.T.M. Committee C-8 on Refractories.

C. E. Imhoff, Allis-Chalmers Mfg. Co., and R. K. Scott, Hall Laboratories, Inc., representing A.S.T.M. Committee D-19 on Water for Industrial Uses.

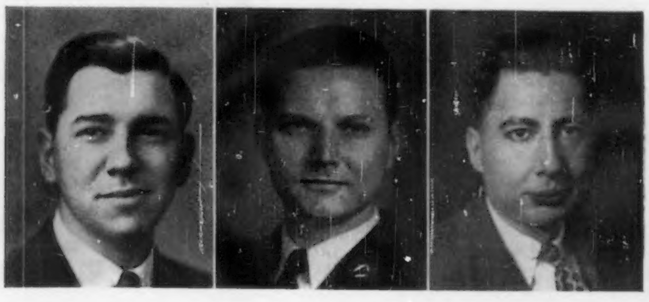
H. Insley, National Bureau of Standards, representing A.S.T.M. Committee C-1 on Cement.

H. H. Lester, Watertown Arsenal, and S. A. Brosky, Pittsburgh Testing Laboratories, representing A.S.T.M. Committee E-7 on Non-Destructive Testing.

The committee with the new additions consists of 26 members. Dr. W. P. Davey of the Pennsylvania State College is serving as chairman and L. K. Freval of the Dow Chemical Co. as assistant chairman. Recently the committee appointed J. W. Caum of the A.S.T.M. staff to serve as permanent secretary.

Continuing the Series of Photographs of Technical Committee Officers—*Upper Left*, Committee C-8 on Refractories: *l. to r.*; R. B. Sosman, Chairman; W. R. Kerr, Secretary; R. S. Bradley, Vice-Chairman. *Upper Right*, Committee D-5 on Coal and Coke; *l. to r.*; D. H. Davis, Vice-Chairman; C. H. Sawyer, Secretary; W. A. Selvig, Chairman. *Lower Left*, Committee B-7 on Light Metals and Alloys, Cast and Wrought: *l. to r.*; Walter Bonsack, Vice-Chairman; J. J. Bowman, Secretary; I. V. Williams, Chairman. Lower Right, Officers of Committee B-9 on Metal Powders and Metal Powder Products; *l. to r.*; W. A. Reich, Chairman; A. Squire, Secretary; W. R. Toeplitz, Vice-Chairman.

Editor's Note.—We usually arrange these in the order of Chairman, Vice-Chairman, and Secretary. This time the instructions to our good engravers went haywire somewhere.



Value of Standards, at American Standards Association Meeting; New Officers

THE legality of standardization, the program of the Munitions Board in bringing about coordinated standards for the military establishment, the organization of company standards work, and methods of evaluating standards were some of the subjects taken up in lively discussions of the question "What Good Are Standards?" at the Thirtieth Annual Meeting of the American Standards Association, October 20 to 22 in New York.

W. John Kenney, Under Secretary of the Navy, spoke on the importance of simplification and standardization to an efficient and economical military supply system and thus to our national security, and described the steps being taken by the Munitions Board to bring about coordination of the standards of the Army and Navy, and Air Force, and to unify them with industry's specifications. John F. Sonnett, partner in the firm of Cahill, Gordon, Zachry, and Reindel, and former Assistant United States Attorney General, discussed the Legal Aspects of Standardization and Earl O. Shreve, president of the Chamber of Commerce of the United States, served as moderator for a panel discussion and made the keynote address at the session of the association and technical society members.

Officers:

New officers for the coming year were announced at the meeting. Thomas D. Jolly, Vice-President in Charge of Engineering and Purchases, The Aluminum Company of America, will be president. Dr. Harold S. Osborne, Chief Engineer, American Telephone and Telegraph Co., and past chairman of the A.S.A. Standards Council, will be vice-president. Dr. Osborne is now serving as vice-president of the United States National Committee of the International Electrotechnical Commission.

W. C. Wagner, Executive Department, Philadelphia Electric Co., was elected vice-chairman of the Standards Council, the technical governing body of the Association, and because of the death of L. F. Adams, Chairman-elect, Mr. Wagner was named Acting Chairman.

Effective in 1949, Mr. Wagner will become Chairman of this important Council. Formerly associated with the Bell Telephone Co., the Western Electric Co., and Stone & Webster Engineering Corp., Mr. Wagner before he came to Philadelphia was a specialist on codes and standards on the staff of the National Bureau of Standards, Washington. A member of several technical and professional groups, including the A.I.E.E., he is active in various civic and other groups in Philadelphia.

Also reelected for the coming year were Vice-Admiral G. F. Hussey, Jr. (USN, ret.), secretary of the Association; and Cyril Ainsworth, technical director and assistant secretary.

Military Standards:

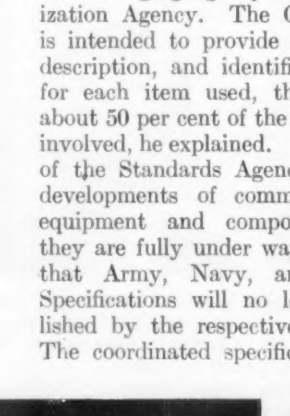
Under Secretary of the Navy Kenny explained two steps have been taken toward coordination of the standards for all the equipment used by the Military Establishment. These are establishment by the Munitions Board of its Cataloging Agency and its Standardization Agency. The Catalog system is intended to provide a single name, description, and identification number for each item used, thus eliminating about 50 per cent of the 5 million items involved, he explained. The operations of the Standards Agency will include developments of common designs of equipment and components. When they are fully under way it is planned that Army, Navy, and Air Force Specifications will no longer be published by the respective departments. The coordinated specifications will be National Military Establishment ("NME") specifications.

One of the objectives of the standardization program is to bring the characteristics of military items into as close alignment with commercial items as is compatible with combat effectiveness. But experiments recently made in the Persian Gulf to test equipment made to Navy standards, and equipment made to commercial standards, show that complications arise due to out-of-the-ordinary geographic and climatic conditions or special combat needs.

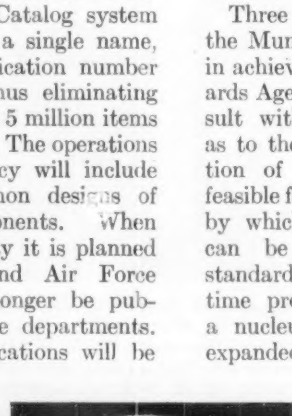
Three working groups appointed by the Munitions Board as an initial step in achieving the objective of the Standards Agency have been directed to consult with representatives of industry as to the extent to which standardization of certain commercial items is feasible for military purposes; the means by which technological improvements can be incorporated into selected standardization designs; and peacetime production planning to develop a nucleus of facilities which can be expanded for wartime production.

Note from editors: Abstracts of several papers in the A.S.A. sessions are being prepared, and will appear in the January ASTM BULLETIN. These papers should be of much interest to many of our members.

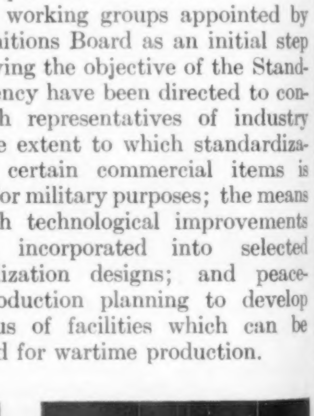
Papers presented at the Panel entitled "Practical Answers to a Practical Question—What Good Are Standards?" include the following: "What Good Are Standards in Specifying and Purchasing Manufacturing Materials?"—Vincent de P. Goubeau, Director of Materials, R.C.A. Victor Division, Radio Corporation of America; "What Good Are Standards in Manufacturing?"—Harold L. Hoefman, Vice-President of Manufacturing, Link Belt Co.; "What Good Are Standards in Marketing?"—R. C. Sogge, Executive Department, General Electric Co.; "What Good Are Standards to Wholesalers and Retailers?"—Gerald C. MacDonald, Manager, Merchandise Testing and Inspection Department, Montgomery Ward and Co.; "What Good Are Standards to the Ultimate Consumer?"—Mrs. Carol Willis Moffett, Director, American Standards Association.



Thomas D. Jolly



W. C. Wagner



H. S. Osborne

The Failure of Metals by Fatigue

FATIGUE has been a subject of great interest to many members of A.S.T.M. from the very early days of the Society. Almost every year our *Proceedings* have contained a number of papers on this subject. It is not surprising, therefore, in looking over the contributors to the Symposium held at the University of Melbourne, Australia, in December, 1946, to note the names of several members of our Committee E-9 on Fatigue, including Prof. H. F. Moore of the University of Illinois and L. R. Jackson of Battelle Memorial Institute.

In the foreword of the book, Dr. H. J. Gough states "By organizing and publishing a comprehensive discussion on the subject of the fatigue of metals, the University of Melbourne has rendered a signal service to a wide circle of scientists and engineers throughout the world. It is indeed appropriate that such a pooling of experience and interchange of thought and opinion should take place at the present time, following the long years when a world war inevitably arrested that free interchange of ideas which is an essential to the advancement of scientific knowledge. In this subject the necessity for the solution of certain practical and pressing wartime problems naturally led to much information being obtained which is of considerable interest and direct value to the designer. Many of the valuable papers presented to the meeting deal with such problems and their partial or complete solution; this volume will therefore be an indispensable addition to the bookshelves of all concerned with the design, development, or maintenance of machines, structures, and components subjected to cyclic stresses."

The 505-page book just recently published in Australia contains thirty papers with 89 illustrations in half-tone and 98 line figures. It is published by the Melbourne University Press at a price of £2.2.0 which, at the current rate of exchange, is about $8.

1948 Metals Handbook

THE long-awaited new edition of the "Metals Handbook" issued by The American Society for Metals has been completed, and what a volume it is! Aggregating over 1450 pages (page size, 8¼ by 10¾ in.), this handbook has been authored by hundreds of the country's leading metallurgical authorities. These men, many of them active in the work of A.S.T.M. as well as A.S.M., worked through the Metals Handbook Committee, with Taylor Lyman as editor. The non-ferrous section of the book was prepared under the direction of the A.I.M.E. Institute of Metals Division Committee on Non-Ferrous Data.

Any reviewer, attempting to cover this book adequately in reasonable space, has a real problem. It is packed full of tables, charts, extensive lists of references, etc. Perhaps a list of the chapter headings, with the approximate pages respectively included, will serve to give an idea of the large number of subjects covered and the space devoted to them. All told, there are 307 articles in the sections covering general, ferrous metals, non-ferrous metals, and constitution of alloys. A great many of the articles are entirely new, with the others being extensively revised.

	Pages
General Section:	
Definitions and Physical Data	32
Shaping of Metals	38
Welding, Brazing and Soldering	14
Mechanical Testing	56
Nondestructive Inspection	18
Metallurgical Examination and Control	34
Structure and Properties of Metals	62
Fundamentals of Heat Treatment	12
Industrial Heating	32
Surface Treatments	8
Ferrous Metals:	
Steel Compositions and Physical Data	8
Manufacture of Iron and Steel	28
Shaping and Fabrication	46
Testing of Ferrous Metals	34
Structure and Properties of Iron	30
Alloying Elements in Steel	36
Hardenability of Steel	14
Ferrous Metal Products	46
Stainless Steels and Heat-Resisting Alloys	38
Magnetic Materials and Special-Purpose Alloys	20
Heat Treatment of Steel	46
Tool Steels	24
Case Hardening	26
Metallic Coatings	22
Surface Treatments	14
Non-Ferrous Metals:	
General Articles	22
Aluminum and Aluminum Alloys	80
Copper and Copper Alloys	102
Lead and Lead Alloys	24
Magnesium and Magnesium Alloys	58
Nickel and Nickel Alloys	38
Tin and Tin Alloys	14
Zinc and Zinc Alloys	16
Precious Metals	40
Miscellaneous Metals	13
Constitution of Alloys:	
Binary Alloys	95
Ternary Alloys	27

Copies of this valuable reference book which includes a 62-page index and an advertising section of 110 pages, can be obtained from The American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio, at $15 per copy.

Precision Investment Castings

THIS book by Edwin Laird Cady, published by Reinhold earlier in the year, should be of interest and help to all those who are concerned in any way with precision investment castings or who have the problem of producing products or parts in small, medium, or large quantities. The book is well written, with a large number of illustrations (123 figures) and a detailed index. In the words of the author, "if the production process is widely familiar, as would be the case with automatic screw machine operation, the best way to organize a technical book regarding that process would be in neat compartments like a mail order catalogue, so that the engineer could turn immediately to the pages he needed. But precision investment casting is far from being widely familiar to engineers. Therefore, a carefully calculated attempt has been made in this book to put each bit of information where the engineer will need to be considering it and thus to eliminate unnecessary checking back and forth in the smoothening of his designs and production plans.

"The first few chapters should serve to tell the engineer what precision investment casting is, what it does, and how it does it. From these chapters he can make up his mind as to whether precision investment casting has anything to offer him or not, and whether it is a process which he should operate in his own shop or one for the products of which he should turn to outside suppliers.

"Any plan to make use of a production process, and especially of a new process, requires a sharing of the burdens of analysis and of responsibility for results. The remaining chapters, therefore, go on to tell the engineer what must be done in product design and re-design in order to get the best results from precision investment casting, and how the process can be operated to obtain the desired ends. The resources and weaknesses of the process are described, the predictable lines of its future development are clearly indicated, and the practical methods by which the process may be operated on a sound basis are analyzed."

Copies of the publication, which aggregates 364 pages, can be procured from the publishers, Reinhold Publishing Corp., 330 W. 42nd St., New York 18, N. Y., at $6.

Mechanics of Materials

THIS 307-page book by Dr. Glenn Murphy, Professor of Theoretical, and Applied Science, Iowa State College who has assisted in compiling the Selected A.S.T.M. Standards for Students in Engineering, has been designed to accomplish certain objectives; in his words: to direct the student's attention to principles useful in explaining observed phenomena, to acquaint him with standard procedures of analysis to understand the bulk of engineering literature, to provide problems as a test of subject understanding, and to make him aware that our knowledge of materials is constantly growing—that a knowledge of material mechanics is an invaluable tool used intelligently.

The author mentions in the preface that he found helpful many stimulating discussions with Professor H. J. Gilkey, Head, Theoretical and Applied Science Dept. at Iowa State College and long standing A.S.T.M. member, in including those topics which normally comprise a first course in mechanics or strength of materials. The statics, the geometry, and the properties of the materials have been used throughout as a starting point in each type of stress situation, but a minimum of emphasis has been placed on formulas as such.

Chapter headings will indicate the general topics covers: Stress, Strain and Axial Loading; Joints an Connections for Axially Loaded Members; Torsion; Stresses in Flexural Members; Deflection of Flexural Members; Statically Indeterminate Beams; Columns; Combined Loadings; Dynamic and Repeated Loads.

With appendices of properties of sec-

tions and problem answers and an index, page size 6 by 9 in., this book is available at $4.50 per copy from the Irwin Farnham Publishing Co., 3201 South Michigan Ave., Chicago 16, Ill.

1948 Municipal Year Book

AN AUTHORITATIVE résumé of activities and statistics and data on American cities is provided by the 1948 Municipal Year Book. While the chief purpose of this latest edition is to provide municipal officials with pertinent information, the book will be of service to all of those who are involved in municipal work or have contacts with it.

New features of the 1948 edition are data on the type of personnel organization in each city, municipal policy on employee unions, airport management and revenues, cemetery management, taxicab regulation, sewer service charges, and certain fire and police activities. The finance section contains information reported by hundreds of cities on new local nonproperty taxes adopted in 1947. There is new material on administrative research and municipal reference libraries. Other important municipal activities are covered such as planning and zoning, public welfare, housing, public works, and the like. A section covering directories of officials comprises 55 pages.

The book has a detailed subject index, and in all covers 560 pages. Bound in cloth it can be obtained at $8.50 from The International City Managers' Association, 1313 E. 60th St., Chicago 37, Ill.

Colorimetric Methods of Analysis

THE third edition of this book by Foster Dee Snell and Cornelia T. Snell, published by D. Van Nostrand, Inc., New York, covers some 250 pages with 109 figures and 50 tables.

Volume I is a discussion of theory, instrumentation and pH. No. colorimetric methods are described. The treatment of theory is brief. Instrumentation covers all types: visual comparators, filter photometers and spectrophotometers. About a third of the book is devoted to colorimetric pH—theory, buffers, and determination.

Chapters that would interest those dealing with plant photometric work are: Colorimetric Methods, Filters, Accuracy, Calculations.

While it is not possible to cover the entire field in a volume of this size, sufficient information has been assembled—together with a number of references—to make this book valuable for one interested in photometric analysis.

Copies of the book, page size 16 by 23.5 mm., are $4.50 each.

Engineering Materials, 2nd Edition

THE NEW edition of this excellent textbook by Albert H. White, Professor Emeritus of Chemical Engineering, University of Michigan, has been revised throughout. The chapters on alloy steels and light metals have been almost completely rewritten. The material on wood, plywood, and other laminates, and protective coatings is almost all new. Most recent developments in the materials of airplanes, lightweight trains, and prefabricated houses are thoroughly covered. Diagrams have been redrawn and new illustrations substituted for old to correspond with the new material added.

The aim of this text still remains to present the various subjects with enough theoretical explanation in regard to behavior of materials to afford their intelligent utilization. Professor White, a member of the Society since 1909, refers to the A.S.T.M., its function, status, and publication of standards, to the work of its technical committees in establishing standards, and to numerous A.S.T.M. standards in specific instances throughout the entire text.

This 686-page book is available at $6 per copy from the McGraw-Hill Book Co., 330 West 42nd St., New York 18, N. Y.

Prevention of Iron and Steel Corrosion

A VERY unique, compact and useful book, titled "Prevention of Iron and Steel Corrosion" by C. Dinsdale, has just come to our attention. This publication contains an outline of the processes used in this field and tabulates the published specifications that are applicable to these several processes. Specification coverage is world-wide and, as might be expected, a great many A.S.T.M. specifications are referenced.

The first part of the book deals with Methods of Preventing Corrosion and has sections on Metallic Coatings; Oxide, Chromate and Phosphate Coatings; Oil Paints, Enamels, Lacquers and Tars and Bitumens; Plastic Coatings; Vitreous Enamelled Coatings; Organic Preventives; Concrete, Cement, Rubber and Asbestos Coatings; Paper Wrappings; Dehydration Methods; Electrolytic Methods; and Water Treatment.

The second and third parts are much briefer and deal, respectively, with Cleaning Metal Parts, and Codes of Practice.

The first appendix gives a list of the authorities issuing specifications that are referenced in the book. While, as noted, the coverage is world-wide, those in the United States and British Empire comprise over half of the list.

Appendix 2 is a list of Paint and Paint Component Specifications which is quite thorough and complete. These are grouped under thirteen headings as follows: Painting Terms, Codes and Schedules; Pigments and Pastes for Oil Paints; Extenders; Ready Mixed Paints; Drying Oils; Thinners; Driers; Shellac, Varnishes, Gold Size; Paint Removers; Enamels; Lacquers and Lacquer Materials; Tars and Bitumens; and Paint Testing.

The book is published by Louis Cassier Co. Ltd., Dorset House, Stamford Street, London, S. E. 1 and distributed at a list price of 5s.

Education for Professional Responsibility

THE remarks and addresses at a most interesting conference on the interrelations of the various professions comprise this book of 220 pages issued by the Carnegie Press at the Carnegie Institute of Technology. The conference held early in 1948 had been planned for an interchange of experience and ideas by teachers in schools of divinity, medicine, law, engineering, and business. It was clear that a discussion of major problems of professional education which are common to many professions would be very fruitful. Those participating were among the leaders in their respective fields, and the addresses give some idea of why the men are outstanding. The points to be stressed are set down in clear, logical fashion, and a number of the printed addresses could be used as examples of excellent exposition.

All those concerned with professional education should find this book interesting and inspiring reading. The viewpoint of engineering was presented by Harry S. Rogers, President of Brooklyn Polytechnic Institute, and a Past-President of the American Society for Engineering Education. While it is not possible to select a statement summarizing the book perhaps the following by Elliott Dunlap Smith, Provost and Professor of Social Relations at Carnegie Institute of Technology, may convey what is embodied in the thinking and expressions of many of the leaders present:

"Certainly in this age, when all men devote by far their greatest interests and energies to their life work, if a man is not cultivated in his understanding of his profession and his practice of it, he is little likely to be so in anything else. The joinder of the social and cultural with the technical in a well-rounded professional education is the essence of preparation for citizenship and cultivated living.

"Let me review the reasons why this is so. If humanistic and social education is to be adequate preparation for citizenship and cultivated living, it must attain, through fundamentally the same methods that have given professional education its vitality and usefulness, vitality and usefullness as a basis for further learning and for problem-solving. If the humanistic and social education of professional students is to be truly cultural and social, it must play an important part in making their life work cultivated and socially valuable. If it is to be an enduring and vigorous force in their professionally predominated lives, it must so unite professional ability and the ability to deal with human and social problems that growth in professional stature involves growth in personal and social stature."

Copies of the publication can be procured from the Carnegie Press, Carnegie Institute of Technology, Pittsburgh 13, Pa., at $3 per copy.

New Members to November 13, 1948

The following 41 members were elected from September 22, 1948, to November 13, 1948, making the total membership 6503.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

Victor Products Corp., W. F. Schroeder, Vice-President, 2635 Belmont Ave., Chicago 18, Ill.

Kominek, Edward G., Project Engineer, Infilco, Inc., 325 W. Twenty-fifth Pl., Chicago 16, Ill.

Wunderlich, Robert A., Superintendent, National Die Casting Co., 3635 W. Touhy Ave., Lincolnwood, Ill.

Cleveland District

Hagar, Donald, Consulting Ceramic Engineer, Box 328, Zanesville, Ohio.

Detroit District

Raynor, C. L., Metallurgist, Hoskins Manufacturing Co., 4445 Lawton Ave., Detroit 8, Mich.

New York District

Davis, Clayton L., Engineer of Tests, Universal Atlas Cement Co., 135 E. Forty-second St., New York 17, N. Y.

Heydegger, Helmut, Instrument Maker, Standard Hydrometer Co., Inc., 8126–28 Margaret Pl., Glendale, N. Y. For mail: 148-19 Eighty-seventh Ave., Jamaica 2, N. Y.

LaRocque, John W., Director of Research, American Flange and Manufacturing Co., Inc., 30 Rockefeller Plaza, New York 20, N. Y.

Long Island Agricultural and Technical Inst., W. G. Truex, Instructor, Highway and Bridge, 520 Conklin St., Farmingdale, L. I., N. Y.

Northern California District

Bethlehem Pacific Coast Steel Corp., Hubert C. Swett, Engineer of Tests, Box 3494, Rincon Annex, San Francisco 19, Calif.

Bethlehem Pacific Coast Steel Corp., Frank C. Smith, Metallurgical Engineer, Box 3494, Rincon Annex, San Francisco 19, Calif.

Ohio Valley District
(In Course of Organization)

Johnson, William H., Foreman, Ultrasonic Inspection, Allison Division, General Motors Corp., Plant No. 5, Maywood, Ind. For mail: 2933 W. Washington St., Indianapolis, Ind.

Philadelphia District

Cook, Willard, Jr., Chief Chemist, Tiona Petroleum Co., 8401 Torresdale Ave., Philadelphia, Pa. For mail: 5718 N. Howard St., Philadelphia 20, Pa.

Hawk, Lester C., Chief Chemist, Penn-Dixie Cement Corp., Nazareth, Pa.

Priester, Max U., Assistant Director, Consulting Div., W. H. & L. D. Betz, Gillingham and Worth Sts., Philadelphia 24, Pa.

Simon, Albert E., Jr., Engineer (Project Development), Carnegie-Illinois Steel Corp., 545 Central Ave., Johnstown, Pa. For mail: 311 W. Mt. Carmel Ave., Glenside, Pa.

Tabas, Daniel M., Structural Engineer, Acorn Iron and Supply Co., Delaware Ave. and Poplar St., Philadelphia 23, Pa.

Pittsburgh District

Rice, James K., Research Engineer, Cyrus William Rice and Co., Inc., 15 Noble Ave., Pittsburgh 5, Pa. [J]*

Snyder, G. M., Executive Metallurgist, Woodings Verona Tool Works, Inc., Drawer J., Verona, Pa.

St. Louis District

Knapp-Monarch Co., D. F. McCarron, Chief Engineer, 3501 Bent Ave., St. Louis, Mo.

Dunning, Randle E., Textile Testing Dept., Merit Clothing Co., Mayfield, Ky. For mail: 213 S. Fifteenth St., Mayfield, Ky.

Washington (D. C.) District

Waterproof Paper Manufacturers Assn., New York, N. Y., Robert C. Reichel, Research Associate, Room 2010, National Bureau of Standards, Washington 25, D. C.

Commons, Charles H., Jr., Chief Ceramic Engineer, Locke, Inc., Box 57, Baltimore 3, Md.

Ostrander, Charles W., Development Engineer, Allied Research Products, Inc., 4004 E. Momument St., Baltimore 5, Md.

Perry, Henry A., Jr., Plastics Research Sub-Division Chief, Naval Ordnance Laboratory, White Oak, Md. For mail: 1032 Flower Ave., Takoma Park, Md.

Western New York–Ontario District

Hall, F. P., Director of Research, Pass & Seymour, Inc., Syracuse 9, N. Y.

Turl, Leslie H., Research and Development Lab., York Knitting Mills, Ltd., 70 Crawford St., Toronto 3, Ont., Canada. For mail: 116 Glenview Ave., Toronto 12, Ont., Canada.

U. S. and Possessions

Columbus Manufacturing Co., Forbes Bradley, Vice-President, Columbus, Ga.

Equinox Mill, Andrew B. Calhoun, President, Box 380, Anderson, S. C.

Wellington Mills, Inc., Aubrey Marshall, President, Anderson, S. C.

St. Paul, City of, Department of Parks, Playgrounds and Public Buildings, Alfred H. Schroeder, City Architect, 445 City Hall, St. Paul 2, Minn.

Smith, Don W., Architect, Texas Bank Bldg., Sweetwater, Tex.

Other than U. S. Possessions

Bird and Co., J. D. Ilett, Technical Assistant, Research Dept., Calcutta, India.

Sociedade Portuguesa Neyret-Beylier and Piccard-Pictet, Lda., Angelo Fortes, Director, Av. Duque de Loule, 95-4°, E. Lisbon, Portugal.

Danish National Institute of Building Research, Niels, M. Plum, Director of Research, 20 Borgergade, Copenhagen, Denmark.

Dubois, P., Managing Director, Centre d'Etudes des Matieres Plastiques, 28 rue St. Dominique, Paris, France.

Jenkins, I., Director, Research Labs., General Electric Co., Ltd., Wembley, Middlesex, England.

Jimeno, Emilio, Professor of Metallurgy, Laboratorio de Metalografia, Faculty of Sciences, University of Madrid, Madrid, Spain.

Kapoor, B. R., Technical Adviser, Turner Hoare and Co., Ltd., Bombay, India. For mail: Worli Point, Bombay 18, India.

Scortecci, Antonio, Professor of Metallurgy and Metallography, University of Genoa; and Vice-President, Italian Association of Metallurgy, Milan, Italy. For mail: Instituto Siderurgico, via Perrone, Genoa, Cornigliano, Italy.

Shehata, F., 13 Adly Pacha St., Box 286, Cairo, Egypt.

* [J] denotes Junior Member.

PERSONALS • • •

News items concerning the activities of our members will be welcomed for inclusion in this column

Note—*Effective in the October* Bulletin *and continuing in this and subsequent* Bulletins *the "Personals" will be arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as the key letter. It is believed this arrangement will facilitate reference to the news about members.*

A. G. Ashcroft, Director of Research, and Development, Alexander Smith and Sons Carpet Co., and an extremely active A.S.T.M. member and presently a member of the Board of Directors, has been elected President of the Textile Research Institute. This group recently held its annual meeting in New York City with a number of interesting papers and reports. To serve with Mr. Ashcroft, Kenneth Wilson of the Forstmann Woolen Co. was elected Vice-President, and Richard T. Kropf, of Belding Hemingway Corticelli Co., Treasurer; D. B. McMaster was reelected Secretary, and H. Wickliffe Rose, Chairman of the Board. According to a news article in the New York *Times* based on addresses at the meeting, Maurice Holland, Industrial Research Consultant, urged that the textile industry step up its research program. Mr. Holland suggested that expenditures for research could be the best form of industrial insurance and that America must no longer depend upon the advanced science and technology of Europe. It was mentioned that this industry probably spends on research less than 1 per cent of sales, whereas the chemical industry figure was noted as about $2\frac{1}{2}$ per cent, with some of the larger companies expending as much as 5 per cent of sales for development work.

Mr. Ashcroft, in welcoming the members of the new Board of Directors, brought to their attention the challenge of the rapidly increasing impact of research in the textile industry and the growth of the Textile Research Institute during the past two years. He noted that research activity of the Textile Research Institute has been almost doubled by the introduction during the past six months of the four-year Research Project on Wool and the five-year Research Project on Dyeing. The wool research project officially started in November with a luncheon at the Waldorf-Astoria at which Senator O'Mahoney was the leading speaker. This is a joint effort on the part of the International Wool Secretariat, U. S. Department of Agriculture, the American Wool Council and the Textile Research Institute to undertake a study of the fundamental properties of wool fibers in an effort to broaden the uses

of wool in consumer products. The dyeing project, sponsored by a group of American manufacturers of dyestuffs and synthetic fibers, will undertake fundamental research on dyestuffs and dyeing methods.

Many active members of the Textile Research Institute are affiliated with A.S.T.M. and carry out valuable work in Committee D-13 on Textile Materials and in other A.S.T.M. activities.

John B. Calkin, Coordinator of Research for Union Bag & Paper Corp. for the past five years, has formed his own consulting business in the pulp and paper, and chemical process industries, with offices at 500 Fifth Ave., New York City.

LaVerne E. Cheyney, formerly Research Engineer with the Battelle Memorial Institute, is now Research Director, Waterproof-Ohio Paper Co., Middletown, Ohio.

Miles N. Clair, Vice-President, The Thompson & Lichtner Co., Inc., Brookline, Mass., extended welcome greetings to visiting civil engineers at the Fall Meeting of the American Society of Civil Engineers in Boston. Mr. Clair, who is President of the Northeastern Section of ASCE, is currently Vice-Chairman of A.S.T.M. New England District Council, having served as Secretary of the District for the past two years.

Harry P. Croft is now Vice-President in Charge of Development, Wheeling Bronze Casting Co., Moundsville, W. Va. He was formerly Director of Technical Control and Research, Chase Brass & Copper Co., Inc., Cleveland, Ohio.

John J. Crowe, Assistant Vice-President, Air Reduction Sales Co., Murray Hill, N.J., is the 1948 recipient of the Samuel Wylie Miller Medal awarded annually by the American Welding Society for "conspicuous contributions to the advancement of the welding or cutting of metals."

T. R. Cunningham, for many years representative of his company on Committee B-4 on Electrical Heating, and Committee E-3 on Chemical Analysis of Metals, has retired from Union Carbide and Carbon Research Laboratories, Inc., New York City.

W. J. Dawson, Chief Metallurgist and Director, Hadfields Ltd. East Hecla Works, Sheffield, England, recently retired after a very active business life at the Hecla Works for almost 50 years. Mr. Dawson is an Honorary Vice-President of the British Iron and Steel Institute, and was also honored earlier this year by conferment of Commander of the Order of the British Empire in recognition of his numerous accomplishments in research during the last 30 years.

John L. Everhart has accepted a position as Metallurgist with the American Smelting and Refining Co., Perth Amboy, N. J. He was formerly on the research staff of Battelle Memorial Institute.

Louis Max Eyermann, II, who has been associated with the U. S. Veterans Admn., St. Louis, Mo., as Adjudicator, is now Lawyer with Roberts & Eyermann, Louisville, Ky.

William F. Finkl, President of A. Finkl & Sons Co., Chicago, has been elected to membership on the Board of Trustees of Illinois Institute of Technology.

William Robert Franklin, former Commander, CEC, U. S. Naval Reserve, has returned to civilian life, and is now Superintendent, Boudwin Construction Co., Reno, Nevada.

Allen S. Ginsburgh, formerly Engineer, United Aircraft Corp., East Hartford, Conn., is now a Graduate Student at Harvard University.

John R. Graf has returned to civilian life and is now Engineer, John C. Graf Co., Philadelphia. He was formerly Captain, U. S. Dept. of the Army, Ordnance Dept.

Samuel S. Gutkin has been promoted to Vice-President and Technical Director, Falk and Co., Pittsburgh, Pa.

Walter R. Hedeman has retired after more than forty-five years of loyal and efficient service as Engineer of Tests with The Baltimore & Ohio Railroad Co., Baltimore, Md. He is succeeded by **R. W. Seniff** formerly Engineer of Tests, The Gulf, Mobile & Ohio Railroad Co., Bloomington, Ill. Mr. Seniff will also replace Mr. Hedeman as representative of the B&O Co. membership in A.S.T.M.

Harry K. Ihrig was recently elected Vice-President and Director of Laboratories of the Globe Steel Tubes Co., Milwaukee, Wis. Dr. Ihrig, who has been with Globe Steel since 1934, is author of the book, "Outline of the Metallurgy of Iron and Steel."

L. B. Jones has joined the retired list of the Pennsylvania Railroad Co. As Engineer of Tests Mr. Jones has been active for many years in A.S.T.M. technical committee work. He plans to continue affiliation with the Society and interest in certain committee work including service on Administrative Committees on Standards and Simulated Service Testing. He has recently moved to Paoli, Pa., and will reside at 23 South Valley Rd. Lloyd, as he is affectionately known by a host of associates and friends in the Society, has rendered outstanding service to the Society in many phases of its work, perhaps most notably in Committee A-1 on Steel. He was concerned with many problems in the railroad field including not only materials and testing but locomotive design and other matters.

M. A. Pinney is succeeding Mr. Jones as Engineer of Tests and will continue the Pennsylvania's contacts on many of the A.S.T.M. committees.

Frank A. Leibold, Jr., formerly associated with Cole & DeGrof, San Francisco, Calif., is now Chief Chemist, Irwin Paint Co., Berkeley, Calif.

Charles Doak Lowry, Jr., who served for some time as Executive Director, Panel on Petroleum, Research and Dev. Board Washington, D. C., has returned to Chicago, and is now Executive Director of the Universal Oil Products Co.

Laurence B. Manley has retired as Specification Writer with the Department of City Transit, Philadelphia, Pa.

Frank J. Mehringer, formerly Instructor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., is now Research and Development Engineer, Victory Plastics Co., Hudson, Mass.

Reid Thompson Milner, one of the country's leading soybean oil chemists, has been appointed Director of the **Northern Regional Research Laboratory,** Peoria, Ill., which functions under the U. S. Department of Agriculture's research administration.

Ralph Alton Moyer has been appointed Professor of Civil Engineering and Research Engineer, Inst. of Transportation and Traffic Engineering, University of California, Berkeley. He was formerly on the faculty of Iowa State College, Department of Highway Engineering.

William H. Parché has announced opening of his own office as Consultant, Bearings and Lubrication, in Niagara Falls, N. Y. Until recently Mr. Parché had been associated with The Carborundum Co. of the same city as Lubrication and Bearing Engineer.

E. W. Patterson, formerly Director Southern Petroleum Labs., Houston, Texas, is now Chief Chemist, Sunray Oil Corp., Duncan, Okla.

George A. Rahn has been appointed Materials Engineer, Pennsylvania Turnpike Commission, Harrisburg, Pa. He was previously Engineer of Materials and Construction, Highway Research Board, National Research Council, Washington, D. C.

Edwin B. Ricketts has retired as Mechanical Engineer of Consolidated Edison Co. of New York, Inc. His home address is 149 Hawthorne Ave., Flushing, N. Y.

Rand Rodgers, President of the Alton Brick Co., St. Louis, Mo., has been elected Vice-President of the Structural Clay Products Institute, Washington, D. C.

John A. Schuch, formerly Detroit Representative of the Applied Research Laboratories, is now Chief Engineer, Harry W. Dietert Co., Detroit.

Edwin T. Sherwin has accepted a position as Chief Engineer, American Linen Supply Cos., Chicago. He was formerly associated with the Duquesne Light Co., Pittsburgh, Pa.

John W. Leslie, President and General Manager of the **Signode Steel Strapping Co.,** Chicago, has been elected a member of the Board of Trustees, Illinois Institute of Technology.

Ludwig Skog, Senior Partner of Sargent & Lundy, Chicago firm of Consulting Engineers, has been elected to membership on the Board of Trustees of Illinois Institute of Technology.

Earl B. Smith has retired from active duties as Professor of Mechanical Engineering and is now Professor Emeritus at the College of the City of New York. Professor Smith is a long-time A.S.T.M. member, his affiliation dating from 1906, and has served throughout the years on several technical committees.

Rolla H. Taylor, formerly Associate Rubber Technologist, National Bureau of Standards, Washington, D. C., is now Rubber Technologist, U. S. Dept. of Agriculture, Salinas, Calif.

Arthur J. Tuscany, Arthur J. Tuscany Organization, Trade Association Organization and Management, Cleveland, Ohio, was honored by the Gray Iron Founders' Society at its recent annual meeting by presentation of an illuminated scroll award, in recognition of his accomplishments in the formative period of this national trade association. The scroll reads: "Gray Iron Founders' Society, Inc. honors Arthur J. Tuscany for his helpful, friendly cooperation with the members of the Society; for his years of service as the Society's first general administrative officer and for his untiring devotion to the task of helping to guide the Society during its early and formative years." Before establishing his own office, Mr. Tuscany had been chief operating executive in the national trade association for seven years. An active A.S.T.M. member, Mr. Tuscany has been Chairman of the Cleveland District Council for the past eight years.

George H. von Fuchs recently resigned as Chemist with the Shell Oil Co., Inc., Wood River, Ill., to enter the consulting field, having signed a contract with the Union Carbide and Carbon Corp., Niagara Falls, N. Y., as consultant.

Leon R. Westbrook, formerly on the faculty of the Case Institute of Technology is now Secretary-Treasurer, Carl F. Prutton & Associates, Inc., Cleveland, Ohio.

NECROLOGY

JOSEPH A. ASHWORTH, Member of Technical Staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J. (November 3, 1948). Member since 1937. As member of Committee A-6 on Magnetic Properties, and representative of his company in that committee, he was active in many of its subgroups including the Subcommittee on Correlation of Magnetic Testing Equipment and Methods, of which he was Chairman. A specialist in the study of magnetic materials, Mr. Ashworth helped in the development of magnetic mines and mine detectors during World War II, and since the war had aided in Bell Laboratories' development of several new types of materials. A native of New Jersey, Mr. Ashworth was born in Kearny in 1910, and was graduated in 1935 from the California Institute of Technology. Besides his wife, Mrs. Eva Millin Ashworth, he is survived by a son, Joseph, Jr., 10, and a daughter, Virginia May, 7.

DAVID GRIMES, Philco Radio and Television Corp., Home Radio Dept., Philadelphia, Pa. Consulting Member of Committee D-9 on Electrical Insulating Materials, Subcommittee III on Plates, Tubes, Rods and Molded Materials.

GROVER C. HOLDER, Chemist, Foster Wheeler Corp., Carteret, N. J. (September 8, 1948). Representative of Company Membership since 1920. He also represented his company on Committees A-1 on Steel, A-3 on Cast Iron, B-2 on Non-Ferrous Metals and Alloys, and B-5 on Copper and Copper Alloys, and many subcommittees of these groups.

LAWRENCE B. JACKSON, Director of Engineering, Diesel Div., American Locomotive Co., Schenectady, N. Y. (July 4, 1948). Member since 1946.

ELMER MCCORMICK, John Deere Waterloo Tractor Works, Waterloo, Iowa (October, 1948). Vice-Chairman of Technical Committee L on Tractor Fuels of Committee D-2 on Petroleum Products and Lubricants.

SIR CLIFFORD C. PATERSON, Director, Research Labs., General Electric Co., Ltd., Wembley, Middlesex, England (July 26, 1948). Member since 1918.

H. H. RATHBUN, Dairymen's League Cooperative Assn., Inc., New York City. Member of Technical Committee L on Tractor Fuels of Committee D-2 on Petroleum Products and Lubricants.

JESSE J. SHUMAN, retired Inspecting Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa. (October 13, 1948). In the death of J. J. Shuman, long-time Inspecting Engineer of the Jones & Laughlin Steel Corp., the Society loses one of its grand old men who had been affiliated since the year the Society was officially incorporated, 1902. Active in numerous phases of A.S.T.M. work in the field of materials, he was particularly concerned with standardization and research work in steel, the corrosion of iron and steel, and such related programs. Following his graduation from Northwestern University in 1890, he entered the steel industry and became Assistant General Superintendent of the Newburgh Steel Works in Cleveland. He had been affiliated with Jones & Laughlin since 1900 until his retirement about two years ago. He suffered a stroke many months ago and although he had made some recovery and was able to get out, his end came suddenly on the above date.

One of the most courteous and friendly of men, Jesse, as he was widely known, made many friends in the Society and in his industry where he was active in the work of the AISI technical committees. He had been chairman of Committee A-1's subgroup on Commercial Bar Steels for almost thirty years.

Many of his friends and associates in the Society will always recall Jesse with his black notebook and busy pen usually sitting in the very front row of the numerous committee meetings he attended. In his passing the Society loses a very loyal member and one who contributed much to its work.

Notes on Laboratory Supplies

Catalogs and Literature; Notes on New or Improved Apparatus

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature:

E. H. SARGENT AND CO., 155 E. Superior St., Chicago 11, Ill. A four-page folder entitled "Polarographic Accessories" lists accessories such as tubes, cups, lamps, electrolysis vessels, burettes, etc. Illustrated.

Also, a four-page folder, "The Sargent Polarograph Model XXI," giving details on the circuit, recording mechanism, control features, specifications of the instrument, dimensions and weight, etc. Illustrated.

Another four-page folder, "The Sargent-Heyrovsky Polarograph Model XII," an electrically driven instrument, utilizing a galvanometer for current measurement and recording the polarogram photographically. Control features, photographic recording mechanism, power characteristics, etc., are given. Illustrated.

Another four-page folder, "The Sargent-Slomin Electrolytic Analyzer," an instrument for high-speed determination of metals. Details on circuit, motor, electrodes, etc., are given. Illustrated.

BURRELL TECHNICAL SUPPLY CO., 1942 Fifth Ave., Pittsburgh 19, Pa. An eight-page folder entitled "Burrell Industro Gas Analyzers," Bulletin No. 213, describes two models, B for the determination of three components such as carbon dioxide, oxygen, and carbon monoxide, and Model C for the determination of carbon dioxide, oxygen, and carbon monoxide and in addition for determining two combustible components such as hydrogen and methane. The bulletin describes simple operation procedure, structural features, etc. Illustrated.

W. H. & L. D. BETZ, Gillingham and Worth Sts., Philadelphia 24, Pa. A twelve-page booklet entitled "Corrosion: Its Effect in Boiler Systems" discussing the cause and prevention of corrosion in boiler systems. The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity, and physical factors are evaluated. Numerous illustrations, graphs, and tables are included.

LEEDS & NORTHRUP CO., 4901 Stenton Ave., Philadelphia 44, Pa. A 24-page catalog, "L&N Pneumatic Control," describing postwar equipment which enables users in the oil, chemical, and other industries to obtain faster start-up, smaller process swings, no process drifts, longer on-stream runs and faster recovery from upsets and shorter turn-around time. Diagrams and test curves are included in the booklet. A complete line of L&N controllers—round chart or strip chart models—speedomax for regulating unusually fast-changing temperatures; Micromax for regulating all other temperatures or per cent SO_2, electrolytic conductivity or pH.

Also, a 32-page illustrated catalog ND44(1), "Micromax Model S indicating Recorders and Controllers," giving complete specifications in convenient, tabular form. Among the indicating recorders are single-point, two-point, and multiple-point instruments which measure the values detected by one or as many as 16 primary elements. Suggested chart

numbers are also listed for the most commonly used ranges, together with other Model S accessories and supplies.

Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md. An eight-page bulletin entitled "Instruments for Measuring Appearance and Other Optical Factors" describes new type instruments for measuring appearance which have been developed by the Gardner Laboratory. Instruments covered are: Portable 60 deg. Glossmeter and 45 deg., 0 deg. Reflectometer, Type P; Multipurpose Reflectometer, Type M; Photometric Unit and Exposure Heads, Type U; Photoelectric Color and Color Difference Meter, Type C; Continuous Recorders and Controllers, Type R.

The Baldwin Locomotive Works, Philadelphia 42, Pa. A series of booklets and leaflets describing strain rate pacer, tubing fatigue machine, vibration table, torquemeters, and other items issued by the Baldwin company.

Bulletin 289—describes and illustrates the new Strain Rate Pacer, a testing machine accessory designed to enable operators to maintain constant straining rates during the loading of test specimens.

Bulletin 275—four pages, covers four standard Baldwin torquemeters of 2000, 5000, 12,000 and 30,000 in. lb. capacity; specially designed torquemeters for capacities of 30 to 750,000 in. lb. capacities; and instrumentation for indicating and recording torque measurements. The bulletin tells how to specify torquemeter requirements and shows how the torquemeter works.

Bulletin 287—four pages, give illustrated descriptions of two cement and concrete testing machines of 90,000 and 300,000 lb. capacities. The bulletin describes construction and operation, weighing and indicating systems, accessories and applications, and includes specifications.

A four-page leaflet illustrating the Baldwin Fatigue Machines that simulate actual service conditions illustrates this equipment and presents ten answers to fatigue testing problems.

Instrument Notes:

The October *Engelhard Industries News-Letter* covered the following equipment and instruments issued by the various companies, part of the Engelhard organization:

Model CR-700 Rectifilter—Charles Engelhard, Inc., 900 Passaic Ave., East Newark, N. J. This device provides a voltage regulated source of low voltage direct current that has been designed to make a compact and rugged unit. Although primarily developed as a source of power for gas analysis, it is usable for many other purposes where a low voltage is desired and the load current does not exceed 300 milliamperes. Such uses are for Wheatstone bridge circuits, vacuum tube circuits using low drain tubes and general laboratory work.

Surface Evaporator Unit—Amersil Co., Inc., 1471 Chestnut Ave., Hillside, N. J. The unit is made entirely of fused quartz. Designed for laboratory and experimental use, it affords many advantages for heating or evaporating of liquids, drying precipitates, and for general use as an infrared source. Available in 300 and 500-watt capacities for operation at 115 volts.

Glass High-Pressure Mercury Vapor Lamps—Hanovia Chemical & Mfg. Co., 233 N.J.R.R. Ave., Newark 5, N.J. An expanding field of use for the radiation of high-pressure mercury arc lamps has stimulated the technological development of ultraviolet transmitting glasses for lamp envelopes. These glasses have a satisfactory transmission to long ultraviolet rays, but will not transmit medium or short ultraviolet radiations in appreciable quantity at the relatively high temperatures at which the high-pressure arc lamps are operated.

Controlled Atmosphere Indicator—Charles Engelhard, Inc. This is designed to detect and indicate the relative oxidizing or reducing qualities of a gas or a combination of gases. This device is particularly suited for heat treating application where the atmosphere to be controlled results from the products of combustion or where the atmosphere is especially prepared.

New Laminated Tubing.—D. E. Makepeace Co., Attleboro, Mass. Large-sized tubing up to 14 feet long, with diameters up to $1\frac{1}{2}$ in., is now being made. Under this method precious metal can be laminated to the inside or outside of the tubing, with close control as to the required ratio.

Theimer Vacuum Adapter—Scientific Glass Apparatus Co., Inc., 49 Ackerman St., Bloomfield, N. J. A new type of glass vacuum adapter for fractional vacuum distillation, which accomplishes the same result more simply than the old type adapters. Contains no stopcocks, but employs an internal glass valve which is automatically lubricated by the distilling liquid. All manipulation is in a three-way stopcock in the pump system, removed from contact with the distillate. Applicable to all types of fractionating, including distillation of medium boiling liquids. Two models are available in a variety of sizes of standard taper or semiball connections. One model, with a jacket around the valve, is used for circulation of coolant when distilling extremely limpid materials or of warm liquid with viscous materials. The other model, without jacket, is satisfactory for normal distillates and has the advantage of lower cost.

Lubricating Oil Testing Kit—The Gerin Corp., Red Bank, N. J. This kit provides means for quick and simple measurements of the condition of lubricating oil. It is especially designed for use by mechanics and engine attendants in garages, power plants, and railroads. It is portable and measures the four dangerous classes of contaminants: change in viscosity due to fuel dilution or other causes; amount of the asphaltic and other oil breakdown substances considered responsible for deposits; amount of dirt, metal particles, other solids and water; acidity, showing whether corrosion is possible.

Speedomax Instrument for Indicating and Recording 160 Temperatures—Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa. This instrument automatically logs as many as 160 separate thermocouple temperatures in succession at a rate of four seconds per point. The equipment consists of two parts, a recorder and a switch assembly—both housed in separate cases.

Model 100-109 Taber Abraser Standard Testing Set—Taber Instrument Co., 111 Goundry St., North Tonawanda, N. Y. Incorporates the rotary abrading action on a 4-in. specimen. A range of standardized abrasive wheels is available for testing all types of surface finishes, including electroplate, porcelain enamel, organic coatings, leather, glass, plastics and woven textile fabrics. The control unit is equipped for dual operation, that is, an additional abraser unit can be located beside and connected with the control unit thus permitting two specimens to be tested simultaneously. This new model is recommended for all modern laboratory setups where general abrasion testing and research are carried on.

Equipment for Testing Ball-Bearing Grease—General Electric Co., Schenectady, N. Y. This equipment is for use under conditions similar to those of field use. It accelerates those conditions which contribute to the destruction of a grease, thereby enabling motor users and grease manufacturers to compare the performance of one grease with another. The tester is a small motor-driven unit with two bearings—one for testing and the other as a guide.

Elmendorf Junior Tearing Tester—Thwing-Albert Instrument Co., Penn St. and Pulaski Ave., Philadelphia 44, Pa. This Tester is a smaller running mate to the Standard Elmendorf Tearing Tester. Although developed primarily for paper and paper products the tester is also used on textiles, metal foils, plastic films, and other sheet materials. The total capacity is 200 grams, suitable for lightweight materials. It is available in any one of four calibrations, reading in grams when testing one, two, four, or eight sheets.

Nefluoro - Photometer — Fisher Scientific Co., Pittsburgh, Pa., and Eimer & Amend, New York, N. Y. A new three-in-one instrument for nephelometric, fluorometric, and colorimetric analyses provides rapid and accurate analyses in all three fields with quick interchange from one to another. The same controls are used for all three types of analysis. This instrument is a line-operated, electronic instrument designed to measure quantitatively, light transmitted (or absorbed), light reflected, or light emitted by a sample in solution or suspension.

The New Hook Connector can quickly be attached to or removed from Flexa frame supports in a number of valuable applications without disturbing other units of the frame. Especially useful for connecting Flexaframe or other ½-in. rods at right angles and as a clamp holder, the new Hook Connector is compact, light, and made of the same bright finish, noncorrosive Castaloy as the rest of the Fisher Scientific Co.'s Flexaframe line.

The Gram-atic Balance—a direct reading analytical balance, it has but one pan; all weighings are made under constant load; weights are removed, not added; it eliminates entirely the handling of weights; it comes to rest quickly; the complete final weight is read directly from the scales on the panel, and the last three decimal places are indicated automatically. This balance has a sturdy aluminum case which almost completely encloses the instrument. The weight indicators and the controls are on the front of the balance and the sliding glass doors can be kept closed after the sample is placed on the pan, thus air currents and eddies within the weighing compartment are eliminated.

A Method of Calibrating Extensometers[1]

By W. C. Aber[2] and F. M. Howell[2]

Synopsis

This paper describes a simple method of calibrating extensometers and other strainometers that is especially suited for verifying autographic extensometers. The degree of precision, while not sufficient for calibrating strainometers used to determine elastic constants, is such that the method appears to be entirely satisfactory for verifying strainometers used for determinations of yield strength.

The method consists essentially of stressing a special calibration bar, the modulus of elasticity of which has been determined precisely, while the strainometer is mounted on the bar in the same manner as during a test. The stressing is carried out in the same manner as in making a tension or compression test, but the stress on the bar is kept well below the proportional limit. Load and strain are measured as in the tension or compression test; if the extensometer being checked is of the autographic type a load-strain curve is drawn, but if the extensometer is of the indicating type simultaneous load and strain readings are determined and plotted. The slope of the line obtained is then compared with the precise modulus line and the degree of agreement is found. Mathematical calculations and experience have proved that even with errors in strain magnification as high as 5 per cent the effect on the yield strength value for aluminum alloys is small.

Time-saving comparison charts are described that enable calibrations to be made very quickly.

The Society has adopted methods for the calibration of load-measuring machines and devices[3, 4] but at the present time there are no generally accepted methods for calibrating strain-measuring instruments. Methods of calibrating strainometers have been under consideration by Committee E-1 for several years and the proposed method prepared by B. L. Wilson and published in the ASTM Bulletin[5] reflected the general thinking of a number of persons concerned with calibration of strainometers at that time. However, there are many details that must be worked out before complete methods are suitable for approval by the Society. It should be recognized that extensometers used only for the determination of yield strength by the offset method need not be restricted to as high a degree of precision as instruments used for the determination of the elastic constants of materials.[6] This paper presents a method that has been found satisfactory for the calibration of extensometers for the determination of yield strength.

Of the many types of strainometers that are used, the autographic devices have found much favor in the inspection testing of metallic materials. In general, the autographic extensometers now available commercially are easy to use, keep the time required to perform a test to a minimum, practically eliminate the personal element, provide a permanent record of the test, and have a sufficient degree of precision to permit the determination of yield strength within acceptable limits.

Currently, there are more than a thousand testing machines in this country that are equipped with autographic extensometers. The Aluminum Company of America has, throughout its various plants, about fifty testing machines that are so equipped. The extensometers are all of the type described by R. L. Templin before this Society in 1932.[7] In these instruments the amount of strain developed in the test specimen is suitably magnified and recorded relative to the load on the specimen. Magnifications of extension can be obtained ranging from 5 to 5000 but those ordinarily provided are 250, 500, and 1000. In testing aluminum and magnesium alloys the strain is usually magnified 500 times. In order to be certain that the strain magnification is being maintained, it is desirable to have a ready means for checking it. A simple method was developed in 1940 and has been used since then for checking our extensometers at suitable intervals with quite satisfactory results.

Calibration of an autographic extensometer by this method consists of applying increasing loads to a special calibration bar made of a material having a relatively high proportional limit with the extensometer attached as in an ordinary tension test. The slope of the load-deformation diagram obtained compared to what it should be, based upon the area of cross-section of the bar and its previously determined modulus of elasticity in tension, is the criterion for determining whether or not the autographic extensometer records values within acceptable limits.

For calibration tests of this kind, it is essential that the special calibration bar be carefully selected and prepared and that its modulus of elasticity be accurately determined. The calibration bar used at the Aluminum Research Laboratories for the past two years was carefully machined from a length of 24S-T4 aluminum alloy rolled-and-drawn rod, $\frac{3}{4}$ in. in diameter. It was machined to the dimensions shown in Fig. 1. The bar is loaded in the various testing machines by means of spherically seated tension bolts and threaded adapters as shown in Fig. 2. After preparation of the bar and before determining its modulus of elasticity, the bar was pre-stressed in tension using the shackles indicated to a stress of 40,000 psi.

The modulus of elasticity of the bar in tension was determined by loading the bar in an Amsler universal testing machine which had been previously

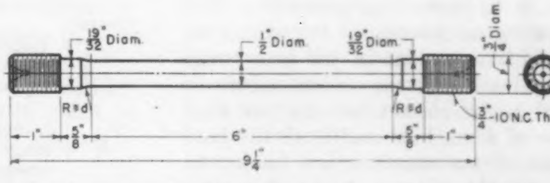


Fig. 1.—Bar for Calibrating Extensometers Having Gage Lengths up to 4 in.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at the Fifty-First Annual Meeting, Am. Soc. Testing Mats., Detroit, Mich. June 21–25, 1948.

[2] Assistant Chief and Chief, respectively, Mechanical Testing Division, Research Laboratories, Aluminum Company of America, New Kensington, Pa.

[3] Tentative Methods of Verification of Testing Machines (E 4 – 47 T), 1947 Supplement to the A.S.T.M. Book of Standards, Part I-B, p. 307.

[4] Tentative Methods of Verification of Calibration Devices for Verifying Testing Machines (E 74 – 47 T), 1947 Supplement to the A.S.T.M. Book of Standards, Part I-B, p. 312.

[5] "Proposed Method of Verification and Classification of Strainometers," ASTM Bulletin, August, 1942.

[6] R. L. Templin and E. C. Hartmann, "The Elastic Constants for Wrought Aluminum Alloys," *N.A.C.A. Technical Note No. 966* (1945).

[7] R. L. Templin, "An Automatic Autographic Extensometer for Use in Tension Tests of Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, p. 783 (1932).

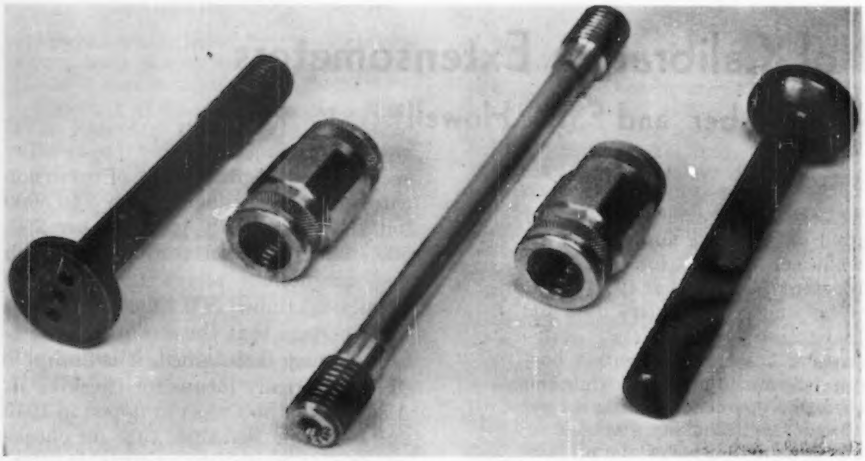


Fig. 2.—Calibration Bar, Threaded Adapters and Spherically Seated Tension Bolts.

calibrated by means of elastic calibrating devices which had been calibrated and approved for use by the National Bureau of Standards. The strain in the bar for the different load increments was measured by means of Tuckerman optical strain gages Nos. 347 and 348, and autocollimator No. B268 which had also been calibrated by the National Bureau of Standards. The modulus of elasticity in tension of the bar was determined by means of a triple calibration, taking into account the small errors in the testing machine and the strain gages. The three determinations of modulus of elasticity were in good agreement with each other, and no single determination differed from the average of the three determinations by more than 0.1 per cent. The average value, 10,500,000 psi., is probably correct within 0.3 per cent.

In use the calibration bar is not stressed beyond its elastic limit and, therefore, can be used indefinitely for checking many extensometers. It is our practice to load the bar to 6000 lb. or less during the calibration of extensometers, depending upon the capacity of the testing machine on which the autographic extensometer is mounted. A load of 6000 lb. on the bar corresponds to a stress of approximately 30,000 psi. which is less than its proportional limit. The corresponding strain is about 0.00286 in. per inch.

The testing machines in our various laboratories have two to seven ranges. It is not necessary, however, to check an autographic extensometer on more than one range of any machine to be sure it is recording correctly. The operating mechanism of the extensometer is independent of the load range being used. If the extensometer is found to be correct on any one load range of a machine and if all the load ranges of the machine are known to indicate the correct loads then the autographic extensometer will record correctly on all of the ranges of the machine.

In making the extensometer calibration tests, it is customary to select a load range of the machine which will permit a relatively long diagram to be drawn for a load of 6000 lb. or less. Most of our testing machines equipped with autographic extensometers have either 5000-, 6000-, 10,000-, or 12,000-lb. load ranges available, and the test bar previously discussed is suitable for checking autographic extensometers when using any of the above ranges.

Since the yield strength value determined by the offset method is affected by an error in strain magnification to a much smaller extent than is the modulus of elasticity value, there is justification for permitting larger errors in strain magnification than one might at first consider acceptable. The only source of error in determining yield strength, attributable to the error in strain magnification, lies in the measurement of offset. If, for example, the strain magnification is 5 per cent higher than the nominal value, the offset measurement should be increased by 5 per cent. If it is not so increased, the yield strength value will be low and the amount by which it will be low is a function of the strain magnification error, the value of offset (usually 0.002 in. per inch), the modulus of elasticity of the material, and its tangent modulus at the yield strength. It can be shown that the error in yield strength is

$$-\frac{EE_TMA}{E - E_T},$$

where:

E = Young's modulus in pounds per square inch,

E_T = tangent modulus at yield strength in pounds per square inch,

M = magnification error of strainometer, and

A = offset.

Thus, if the magnification error is 5 per cent, the offset 0.002 in. per inch, the modulus of elasticity of the material 10,300,000 psi., and the tangent modulus 2,000,000 psi. at the yield strength (as is usually the case for most heat-treated aluminum alloys[8]), the yield strength will be in error by 248 psi. An error in yield strength determination of this magnitude is certainly not very serious. For this reason, we have accepted a value of ±5 per cent as a permissible limit of error in strain magnification.

The procedure for calibrating an autographic extensometer using the calibration bar is very similar to the regular procedure for making a tension test in which the yield strength is determined by means of an autographic extensometer. The principal difference between the calibration test and the regular tension test is that the calibration bar is loaded only to a predetermined stress within its elastic range.

In the procedure adopted, at least three diagrams are drawn for each autographic extensometer being calibrated. The strain follower is removed from the bar after each loading. Then after the three diagrams are drawn the chart is removed from the drum of the testing machine, and the slopes of the diagrams are determined graphically. The slopes are expressed in pounds per square inch, and if the values obtained are in reasonable agreement with each other and the average of the three values does not deviate from 10,500,000 psi. by more than ±5 per cent, then the autographic extensometer is considered to be functioning properly and recording within acceptable limits. Figures 3 and 4 are redrawn copies of typical diagrams obtained on Southwark-Tate-Emery and Amsler universal testing machines equipped with Templin-Type autographic extensometers.

The calculations involved in determining the slopes of the curves are not difficult to make, but a considerable amount of time may be saved if comparison charts are prepared and used for determining whether or not the curves have the correct slopes instead of making separate calculations for each curve. The comparison charts contain lines of maximum and minimum slope for the particular specimen being tested and the testing machine load range being used. In calculating the slopes of the curves or when using the comparison charts for determining whether or not the slopes are within acceptable limits, the upper portions of the curves are given major consideration. The initial portions of the load-

[8] For annealed and cold-worked aluminum alloys the tangent modulus at the yield strength is even less than 2,000,000 psi.

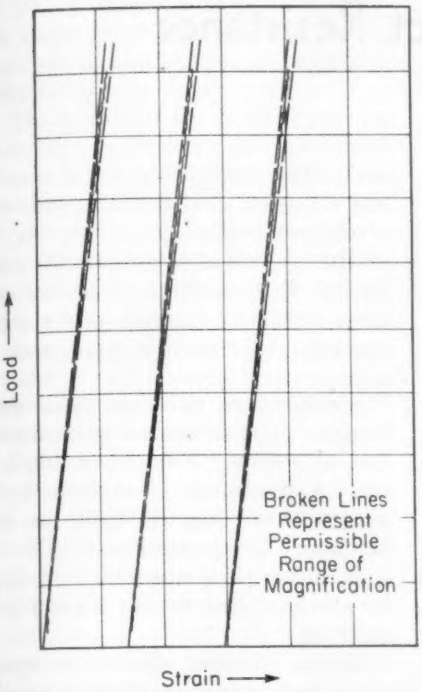


Fig. 3.—Typical Calibration Diagrams for Autographic Extensometers on the Southwark-Tate-Emery Testing Machines.

strain curves are sometimes slightly in error because of difficulties in proper seating of the strain-follower, but this is overcome as soon as a load of a few hundred pounds is applied.

After the comparison charts have been prepared and the diagrams or curves have been drawn, remove the charts containing the diagrams from the testing machine and superimpose them upon the proper comparison chart. If the diagrams fall between the lines representing the maximum and minimum slopes then the calibration is considered acceptable. The time required for the complete calibration is usually less than 30 min.

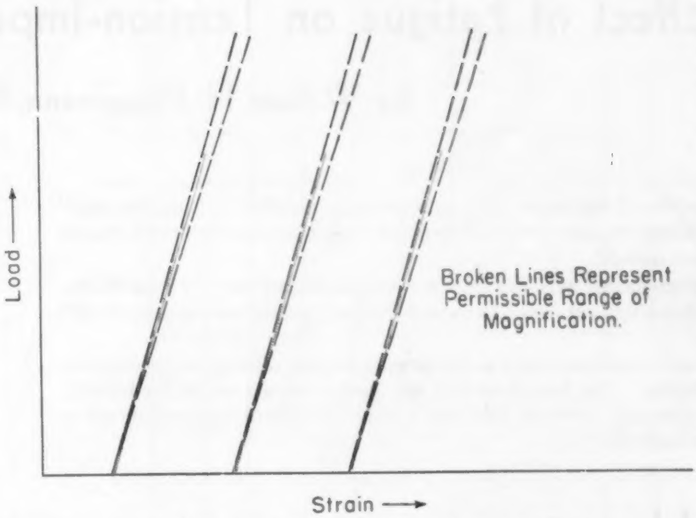


Fig. 4.—Typical Calibration Diagrams for Autographic Extensometers on Amsler Testing Machines.

Calibration of autographic extensometers using a special calibration bar in tension has been emphasized in this paper, but it should be pointed out that the method applies equally well for calibrating autographic compressometers using a specially prepared calibration bar whose modulus of elasticity in compression has been accurately determined. The method is satisfactory also for calibrating other types of strain measuring devices which are not autographic. For such strainometers the apparatus is mounted on a special calibration bar, the bar is loaded by means of a calibrated testing machine, and the load-strain data are recorded in the appropriate manner. Comparison of the calculated modulus of elasticity values from the load-strain data with the previously determined value is the criterion for determining whether or not the strain measuring device is satisfactory for the determination of yield strength.

This method provides a suitable procedure for calibrating strainometers that are used primarily for the determination of tensile or compressive yield strengths of materials having stress-strain curves that are not too steep at the yield strength. The method is simple, requires no expensive apparatus, provides a permanent record, and can be carried out in less than 30 min.

Acknowledgment:

The authors appreciate the helpful suggestions of R. L. Templin, Assistant Director of Research and Chief Engineer of Tests, Aluminum Company of America, in the preparation of this paper.

DISCUSSION

Mr. G. R. Gohn.[1]—I should like to emphasize the authors' closing statement and to point out that this method can also be applied to other materials where the stress-strain curve is not too steep at the yield point. We have successfully employed a similar method, using a steel rather than an aluminum bar for calibrating our own extensometers.

However, I should like to emphasize that if you are dealing with copper-base alloys there is a group of alloys which show very little deviation in the stress-strain curve from the modulus line, and in such cases a permissible deviation of ±5 per cent in the strain magnification would make a very high percentage error in the determination of the yield strength.

Mr. A. A. Moore.[2]—It is contrary to general practice to calibrate only part of the full range of use. The calibration of the test specimen in the elastic range up to 30,000 psi. would give a strain of about 0.003 in. The strains at the yield strength of the high-strength aluminum alloys are in the neighborhood of 1 per cent.

Mr. F. G. Tatnall.[3]—Does not the modulus of elasticity change with temperature and should not the temperature at which the calibration is made be stated?

Mr. F. M. Howell (*author*).—As Mr. Gohn says, there are some materials that show very little deviation of the stress-strain curve from the modulus line at the yield strength—that is, the difference between the modulus at the yield strength and the initial modulus is small. For such materials it would be desirable to limit the permissible error to a smaller value.

Mr. Moore points out that it is contrary to general practice to calibrate only a part of the range of use of an instrument of this kind. That is true, but since the method described provides a reasonable check on the magnification factor, it is considered adequate for the determination of yield strength under the limitations imposed. It is quite possible, however, to use a calibration bar that exhibits more strain at its proportional limit and thus calibrate the extensometer throughout a greater range.

Mr. Tatnall raises the question of the effects of temperature on the modulus. Within the range of temperature ordinarily encountered in the usual inspection tests, the effects on modulus of elasticity are very small. If the extensometer is to be used at other than room temperature, it should be calibrated at such temperatures and, of course, in such cases the temperature should be stated.

[1] Member of Technical Staff, Bell Telephone Laboratories, Inc., New York, N. Y.
[2] Division of Tests, Magnesium Laboratories, The Dow Chemical Co., Midland, Mich.
[3] Manager, Testing Research, Baldwin Locomotive Works, Philadelphia, Pa.

Effect of Fatigue on Tension-Impact Resistance*[1]

By William H. Hoppmann, II[2]

Synopsis

The purpose of this paper is to indicate the possibility of using the high-velocity tension-impact test to determine the loss of impact resistance caused by fatigue in metals.

Tension specimens were cut from a low-carbon steel plate in a known fatigue condition and subjected to impact tests at various velocities up to 120 ft. per sec.

Energy and total elongation as functions of impact velocity are given in the form of graphs. The data show that the tension-impact test at moderately high velocities may have considerable value in studies of fatigue damage to structures in service.

High impact resistance is a property required in many materials used in structures and in machines. In particular, warships must be constructed of metals capable of absorbing large amounts of energy if attacked. During the more or less long periods between attacks, the metals in the ship are fatigued by alternating stresses. This fatigue condition may reduce considerably the impact resistance of those metals. It is important to be a' to predict the magnitude of thi duction as a function of any given number of stress reversals as well as amplitudes of stress caused by action of the sea.

Information is also needed on the extent of prior fatigue damage in a structure which has been in service for some time. In the past, need for such information arose in the aviation field.[3]

It would appear reasonable that both of these problems may be solved by use of the variable velocity tension-impact test.

An extensive investigation of the effects of prior fatigue stressing upon the impact resistance of chromium-molybdenum steel was made about five years ago by Kies and Holshouser.[3] The conclusion reached by those investigators was substantially that no loss in impact resistance occurred as a result of fatigue. They conducted the tension-impact tests on a Charpy machine of 225 ft.-lb. capacity. Although no velocity was stated, it can reasonably be inferred from the general description that it was below 20 ft. per sec.

Inasmuch as structural steels may be subjected to impact at higher velocities in service, it was considered advisable to subject fatigued steel to impact over a range of velocities from zero to 120 ft. per sec.

Material and Tests

A $\frac{3}{4}$-in. hot-rolled low-carbon steel plate was selected for the tests. The chemical composition and physical properties are given in Table I.

TABLE I.—CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES.

Carbon, per cent	0.20
Manganese, per cent	0.36
Phosphorus, per cent	0.010
Sulfur, per cent	0.017
Silicon, per cent	0.00
Nickel, per cent	0.12
Copper, per cent	0.27
Yield stress, psi	35 000
Tensile strength, psi	59 000
Elongation in 2 in., per cent	37
Reduction of area, per cent	62

A portion of the plate about 12 by 60 in. was fitted into a box-like structure which then had alternating moments applied to its ends by a special resonant type fatigue machine. The plate was so located that its test section was practically subjected to alternating tension and compression throughout its thickness. The applied bending moment was adjusted so that the amplitude of the stress throughout the length of the plate was about 28,000 psi. for 37,000 complete reversals of stress. This maximum stress was checked by scratch-type strain gages.

Blanks were then cut from the fatigued plate transverse to its direction of rolling. From these blanks tension specimens of uniform test section 8 in. long by 0.394 in. in diameter were machined. Both ends of the specimens were threaded for about an inch to suit the impact machine.

Similar tension specimens were taken from a portion of the original plate which had not been subjected to the fatigue test. These, also, were cut with their lengths transverse to the direction of rolling.

Both sets of tension specimens were tested in the Guillotine Impact Testing Machine at the Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y. This machine was described in a previous paper.[4]

The impact tests were conducted at a temperature of approximately 75 F. and at velocities up to about 120 ft. per sec.

The total energy absorbed by the specimen and the total elongation over the 8-in. gage length were measured. The results are shown graphically in Fig. 1.

Discussion

The test results show that there is a reduction of approximately 30 per cent both in the energy and in the elongation at the higher velocities.

It may be observed that the difference in results between the fatigued steel and the nonfatigued steel decreases as the test velocity approaches zero. This fact is in agreement with the conclusion of Kies and Holshouser to which reference has already been made.

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* Presented at the Fifty-first Annual Meeting, Am. Soc. Testing Mats., Detroit, Mich., June 21-25, 1948.

[1] The opinions or assertions contained herein are the private ones of the author and are not to be construed as reflecting the views of the Navy Department or the Naval Service at large.

[2] Assistant Professor of Mechanical Engineering at the Johns Hopkins University. Formerly Consultant in Applied Mechanics at the Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y.

[3] Kies and Holshouser, "Effects of Prior Fatigue Stressing on the Impact Resistance of Chromium-Molybdenum Aircraft Steel," *Technical Notes No. 889*, National Advisory Committee for Aeronautics, Washington, D. C., March, 1943.

[4] W. H. Hoppmann II, "The Velocity Aspect of Tension-Impact Testing," *Proceedings*, Am. Soc. Testing Mats., Vol. 47, p. 533 (1947).

The curves for energy are similar to those for elongation and reach maxima at approximately the same velocity of impact.

The results of the tests appear to warrant a more extensive investigation of the loss of impact resistance caused by fatigue.

The results of the tension-impact tests indicate that they may be used to predict the loss of impact strength as a result of fatigue and also may be used to determine the extent of prior fatigue damage to a structure, resulting from alternating stresses in service.

In any future investigation the tension-impact tests should be extended to cover materials subjected to different amounts of prior fatigue. Then data will be provided for a family of curves for energy as a function of impact velocity. The parameter of the family will be the amount of fatigue.

Conclusions

The following conclusions appear to be warranted by the results of the tests, at least for structural steels:

1. The variable velocity tension-impact test provides a means of predicting the loss of impact resistance caused by a given amount of fatigue.
2. The tension-impact test may also be used to determine the amount of fatigue damage developed in a structure in service by testing samples taken from the structure.
3. The reductions in energy and in elongation are larger at the higher impact velocities. The curves of energy absorption have, in general, the same characteristics as the curves of elongation.
4. The loss of impact resistance may be considerable even for cases in which the maximum fatigue stress is below the yield stress. The results given in this paper show a loss as large as 30 per cent even though the maximum fatigue stress was only 28,000 psi.
5. Although the number of specimens tested was not large, the results appear conclusive enough to indicate the value of a more extensive investigation which would include different materials and for wider ranges of the test variables.

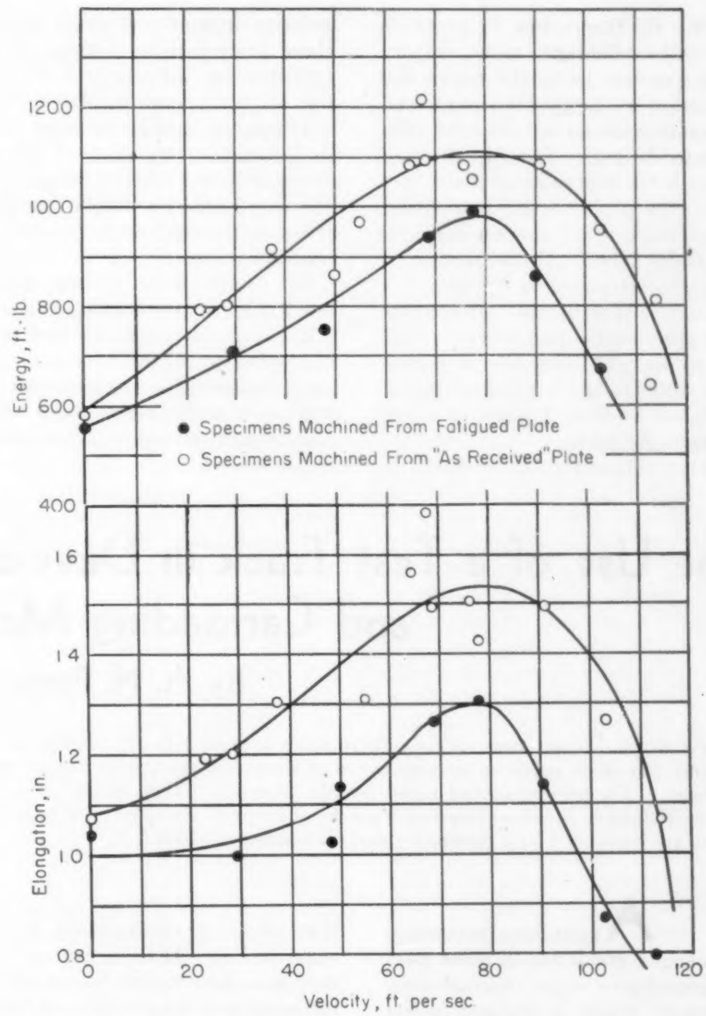


Fig. 1.—Variation of Impact Strength and Elongation with Velocity of Impact.

Acknowledgment:

The author wishes to express his appreciation to the Navy Department for permission to publish the experimental data in this paper.

DISCUSSION

MR. J. A. BENNETT.[1]—I think it should be pointed out that in a fatigue test there are two processes going on: work hardening and fatigue damage. In the work which Mr. Hoppmann referred to, of Kies and Holshouser, the purpose was to evaluate only the fatigue damage. The effect of work hardening occurring during the early part of the test was eliminated by comparing the changes in impact properties during the latter 90 per cent or so of the test, when the changes due to work hardening were small.

I should like to ask if the author has any information on the static mechanical properties of the steel after the fatigue stressing. It has been shown frequently that metals are work hardened during fatigue stressing, even at stresses below the elastic limit, but no correlation has been found between work hardening and fatigue damage. If the changes which the author found in impact resistance are due primarily to work hardening they should show up in the static mechanical properties.

I should also like to ask if the author knows whether or not the stress which he applied was above the fatigue limit? It appears from the original mechanical properties of the steel that probably the fatigue stress was near the fatigue limit, in which case the life would certainly be long and the 37,000 cycles of fatigue stressing which he applied would cause only very slight fatigue damage.

[1] Metallurgist, National Bureau of Standards, Washington, D. C.

MR. W. H. HOPPMANN II (*author's closure*).—Mr. Bennett raises an interesting question as to the reason for the reduction in energy absorption and elongation in tension specimens from the steel plate tested. Indeed, if work hardening is the sole cause of the reduction, then the paper should be entitled "Effect of Work Hardening on Tension-Impact Resistance." However, one of the thoughts advanced in the paper is that ships subjected to alternating stresses apparently lose thereby resistance to impact. This fact is of considerable importance in warship design regardless of whether fatigue or work hardening is the cause.

The other thought that the variable velocity impact test could be used to show prior fatigue damage is not established by the results if the effect is due solely to work hardening.

It may be that I was much too facile in associating the idea of alternating stress with the idea of fatigue and not allowing for the possibility that the main effect on the steel might be one of work hardening.

Of course it is known that work hardening may reduce impact resistance, but it is a new idea to me that the work hardening by 37,000 complete alternations of bending stress of amplitude 28,000 psi. is sufficient to reduce the tension-impact resistance 30 per cent at 80 ft. per sec.

Apparently the static tensile properties were unchanged by the alternating stresses as is indicated by the fact that the energy and elongation shown by the curves at zero velocity (static) are practically the same for the plate which was subjected to alternating stresses and the plate which was not subjected to alternating stresses.

I was aware of the fact that the investigation was not extensive and that it leaves much to be desired, but the data seemed to me to be of sufficient interest to publish. The hope was that the results might stimulate further investigation of the phenomenon of the reduction of energy absorption and of elongation as a function of the velocity of impact.

The Use of a Test Track in Developing Good Packaging and Carloading Methods*

By A. N. Perry[1]

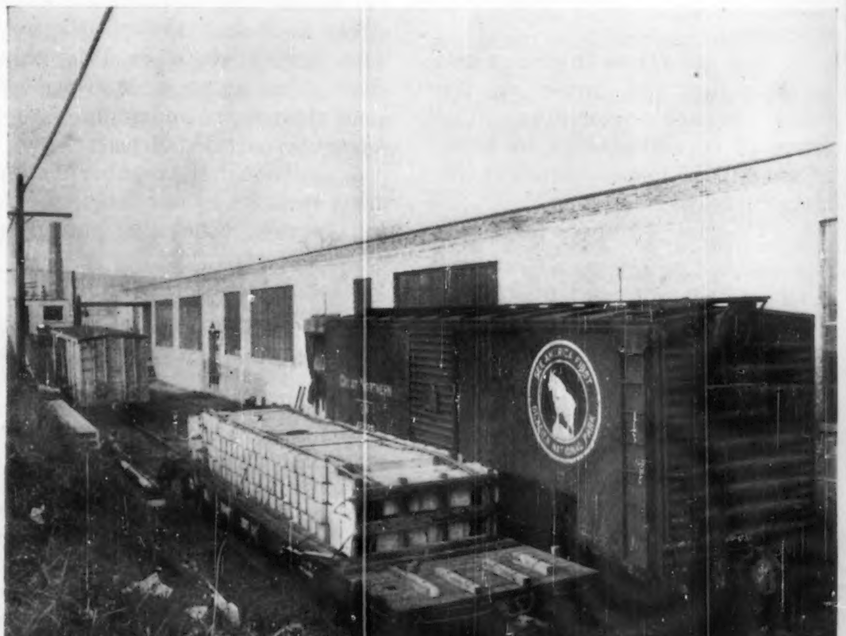
EDITOR'S NOTE.—From time to time there have appeared in the ASTM BULLETIN photographs and short notes on various types of simulated service testing of materials and products. The accompanying paper by Mr. Perry is a type of simulated service testing and we believe the short discussion will be of interest to a number of members and others who are concerned with packaging and car-loading problems.

A VERY large percentage of all packaged goods travel some part of their journey in or on railroad cars. Our company, which is engaged in the manufacture and sale of tensional steel strapping and related items, a very large part of which is used for securing packaged material in box cars, gondola cars, and on flat cars, has constructed a full-scale carloading test track adjacent to our plant in Chicago in order to become better informed as to the factors which cause damage to lading in transit.

This test track is patterned after a similar facility which the Symington-Gould Corp. of Depew, N. Y., has maintained for many years for testing draft gears and other railroad equipment. We use our track entirely in the interests of better packaging and carloading.

The Signode test track installation consists of a standard railway track 315 ft. in length. An inclined trestle is at one end of the track, with a power winch located at the top capable of pulling a loaded freight car up the incline. At the bottom of the incline is a level section of track substantially laid on a concrete bed. At the center of this level section a chronograph is installed which measures and records the speed at which a car is moving before, during, and after impact. Two standard railway cars are part of the equipment: one, a flat car loaded with concrete blocks to a gross weight of 110,000 lb., is used as the bumper car and the second is used as the test car. This is a box car with one side wall removed to permit observations of loads at the moment of impact.

A "tripper" car pulls the test car up the incline to a predetermined point where a "tripper block" releases the coupler—the test car then rolls freely down the incline and collides with the bumper car just as it would in a freight yard. If desired, the test car can be left



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at the point of impact and the bumper car be caused to crash into it.

By actual observation of the action of the lading and bracing, the effect of the end impact, resulting uplift, and disorganization of the load can be noted and studied. There is no doubt that a very large percentage of the lading damaging forces are a result of the collision of cars in switching yards. Since extreme uplift usually occurs, also side shift—forward movement— and relative movement of individual units as a result of this impact, it has been our experience that a load which is properly secured to resist these switching impacts will usually survive any of the other hazards to which it is subjected.

Our standard testing procedure is to start at low impacts within the normal 4 mph. switching range. The force of the impact is increased gradually until failure occurs or the load survives the limit of impacts to which we normally subject a load. This is at 9 to 10 mph. By this method we have been able to test whole carloads of such fragile articles as refrigerators and electric and gas ranges, and make pronounced improvements in the bracing methods. In conducting these tests the reasons for failure are usually detected and corrected before extensive damage occurs to the test loading.

The test track supplements the field activity we have carried on for many years. It is not possible for us to anticipate all the problems that arise in the materials handling and shipping room procedures of the shipper or receiver, or to foresee all of the transportation hazards that are bound to occur. We have, however, often been able to arrive at a satisfactory solution in a few days of controlled testing which previously required weeks of field work and checking of hundreds of cars at destination. In many cases we feel that our findings have been more accurate.

Our test track programs are always carried out in cooperation with the representatives of the shipper. When such commodities as paper rolls, fiber drums, steel coils, and other items not amenable to modification are tested, our problem is entirely one of devising a loading method which will best protect the lading. The ability to properly brace the carload shipment should surely be considered as the ultimate step in container design, as the job certainly is not complete until this detail is attended to. There have been several cases where a change in container construction has been suggested as the result of testing a full carload under actual switching conditions.

For example, a large shipper of stoves was having difficulty. Inspection of dozens of cars at destination usually revealed failures, which consisted of a combination of broken bulkheads, broken straps, and broken containers with resulting damage to the stoves themselves. Several variations of loading methods were tried and inspected at destination without discovering the complete answer to this problem. A carload of newly crated undamaged stoves were brought to our test track. By starting at slow impacts and gradually increasing the speed, it was found that there was a definite weakness in one of the top crate members which caused these crates to start to fail at impacts approximately 6½ mph. The size of this member was immediately changed and a successful load resulted. The weakness had not shown up in the standard laboratory test, but such a test does not subject the crate to the outward crushing effect that occurs when it is placed in a car with its fellow traveling companions.

Another instance is that of a manufacturer of bulk containers who wished to make some improvements in design. After a great amount of research, some changes were indicated. Before going to the great expense necessary to make these changes, a carload of the conventional design and of the proposed design filled with a heavy bulk commodity were given our standard series of impacts on the test track. These tests confirmed that the diagnosis of the weakness was correct and that the improvement planned was the proper one.

I will not attempt to suggest in detail just how valuable a full-scale carloading test track would be in proving out the finer points of container design, but these specific examples of how we have indirectly contributed to better packaging design suggest its possibilities.

Change in Hardness of a Metal Bar Under Low Cycles of Reversed and Pulsating Plastic Bending

By Harry Majors, Jr.[1]

Synopsis

Experiments are described in which the effects of pulsating and reversed bending tests at low numbers of cycles of bending on the hardness of annealed copper-zinc alloy and S.A.E. 1112 annealed steel are determined. The hardness increased with the number of cycles of bending, and no fiber had its original hardness once it experienced a plastic deformation. Alternate tensile and compression strains caused a greater change in hardness than equal strains in one direction only. Compression strains increased the hardness more than equal tensile strains.

Although some work has been done in determining the effect of elastic strains upon hardness, the effects of a few cycles of fatigue bending in the plastic range on the hardness change are not well known.

Working with brass and duralumin, Fink and van Horn,[2] at the suggestion of Jeffries, measured the hardness and the lattice distortion of elastically deformed specimens. Only the tension side of the simple beams was measured, using the Rockwell E scale, in which the maximum fiber strain was 0.003 in. They reported a definite softening from tension strains below the elastic limit, while for strains that exceeded the elastic limit stress the hardening due to plastic deformation opposed the softening action. Cycles of straining were not investigated.

Kokubo[3] conducted experiments in order to test the conclusions of Fink and van Horn and to ascertain the change of Vickers hardness number, using 5 kg., in a plate under pure bending caused by slight deflection. The hardness on the tension and compression sides up to a maximum strain of 0.003 in. per inch was observed on Armco-iron, 0.2 and 0.7 per cent carbon steels, copper, brass, aluminum, dur-

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[2] W. L. Fink and K. R. van Horn, "Lattice Distortion as a Factor in the Hardening of Metals," *Journal*, Inst. Metals, Vol. 44, p. 241 (1930).

[3] S. Kokubo, "Change in Hardness of a Plate Caused by Bending," *Science Reports of the Tohoku Imperial University*, Japan, Series 1, Vol. 21, p. 256 (1932).

TABLE I.—SUMMARY OF KOKUBO'S INVESTIGATION.

Material	Condition	Maximum Strain	Change in Vicker's Hardness Number	Percentage Change in Vicker's Hardness
Armco Iron	Rolled	+0.003	−12.5	− 8.0
	Rolled	−0.003	+ 2.5	+ 2.5
	Annealed	+0.003	+ 1.0	+ 1.0
	Annealed	−0.003	+ 4.0	+ 5.0
0.2% steel	Rolled	+0.003	−15.0	−11.0
	Rolled	−0.003	+ 2.5	+ 2.0
	Annealed	+0.003	− 8.0	− 7.0
	Annealed	−0.003	+ 1.0	+ 1.0
0.7% steel	Rolled	+0.003	−22.0	− 9.0
	Rolled	−0.003	+ 2.0	+ 1.0
	Annealed	+0.003	−14.0	− 6.5
	Annealed	−0.003	+ 5.0	− 3.0
Brass	Rolled	+0.003	−16.0	−12.0
	Rolled	−0.003	+ 3.0	+ 2.0
	Annealed	+0.003	− 2.0	− 1.5
	Annealed	−0.003	+ 2.0	+ 3.0
Aluminum	Rolled	+0.003	− 2.0	− 5.0
	Rolled	−0.003	+ 1.0	+ 2.0
	Annealed	+0.003	+ 0.7	+ 4.0
	Annealed	−0.003	+ 1.2	+ 6.0
Copper	Rolled	+0.003	− 9.0	−10.0
	Rolled	−0.003	0.0	0.0
	Annealed	+0.003	0.0	0.0
	Annealed	−0.003	+ 4.0	+ 8.0

alumin, and magnesium. Kokubo concluded for his range of strains that the hardness of the tension side of a cold-rolled specimen decreases at first rapidly and afterwards slowly, while that on the compression side always increases slightly with an increase in the degree of bending. For annealed specimens it was found that the hardness decreases rapidly at first, and after passing through a minimum then starts to increase slowly with an increasing amount of bending. Kokubo attributes the change of hardness caused by elastic deformation to the effect of the applied stress and that caused by the plastic deformation as the combined effect of the stress and of work hardening. There were no reversed or pulsating bending tests.

The purpose of this research was to determine the effect of reversed and pulsating plastic bending cycles upon the change in the Vickers hardness number.

Material and Specimens

From a 20 ft. long, 1-in. square bar of S.A.E. 1112 steel, a piece 12 in. long was cut. A similar length was cut from 1-in. square brass stock whose copper content was 65 per cent and zinc content was 35 per cent. Both specimens were surface ground on four sides and polished with emery cloth and paper. Upon the steel specimen 18 lines were ruled longitudinally with a diamond inscriber on one side in the center area as shown in Fig. 1. By cross-ruling six lines at right angles, transversely to the span, and designating each group of two as columns *A*, *B*, and *C*, 20 gage lengths were thus formed on the steel specimen. Nineteen lines were scribed on the brass specimen, and when six lines were cross-ruled, 21 gage lengths were formed in column *B* as indicated in Fig. 1.

Prior to scribing, the steel was packed with charcoal in a closed tube and annealed at 1650 F. for 3½ hr., after which it was furnace cooled to a Vickers hardness of 138. The brass specimen was held at 800 F. in a vertical hot air furnace for 3½ hr. and slowly cooled to an approximate hardness of 100.

Testing Procedure

In column *B* the initial gage lengths were measured with a cathetometer to the nearest 0.0001 in., and at the opposite side initial hardness measurements were made at every 0.05 in. as well as on the top and bottom fibers. Figure 2 shows the steel bar in the testing apparatus. The bars were bent with two point loading producing pure bending in the center section. Sufficient load was applied to cause a deflection at the center of 1 in. when the load was removed. Gage lengths in column *B* were measured and hardness readings were made with the Vickers hardness machine on the opposite side every 0.05 in. This was termed the first bending. Then the bar was bent back straight, and the gage lengths measured and hardness values observed. This was termed the first straightening and concluded one cycle of pulsating plastic bending. As indicated in Fig. 3, the procedure for performing a pulsating plastic bending

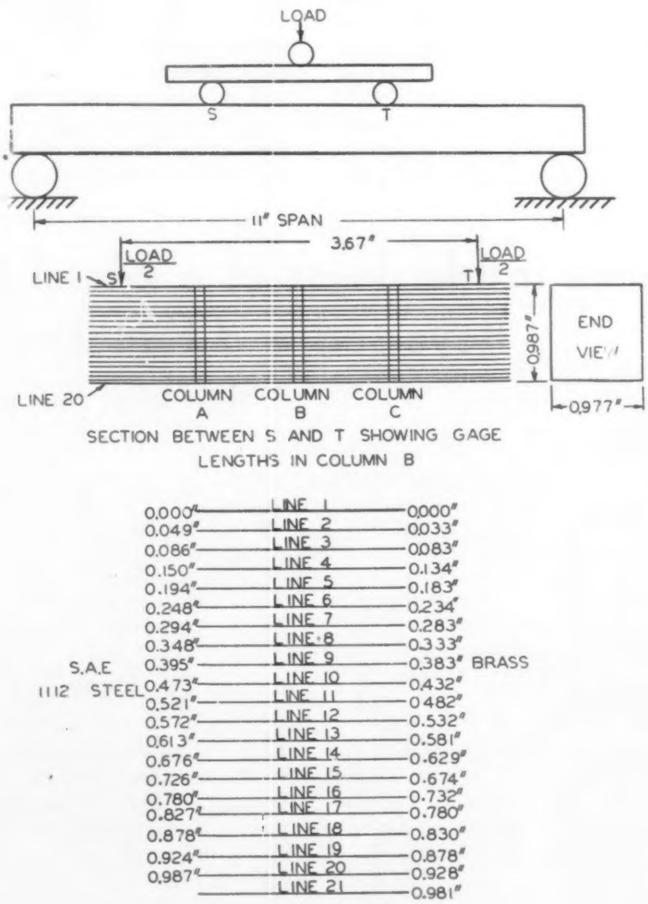


Fig. 1.—Arrangement of the Beam in the Testing Machine Showing the Location of the Diamond Ruled Gage Lengths.

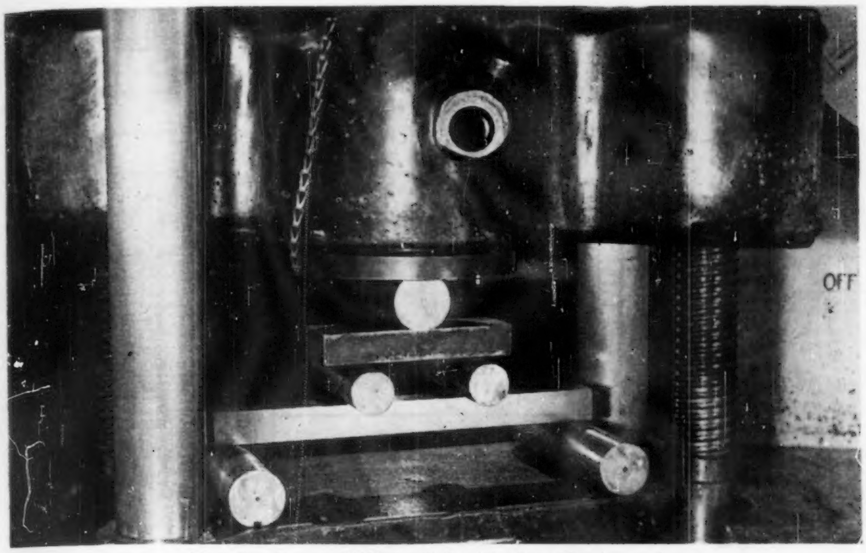


Fig. 2.—General View of the Testing Equipment.

cycle was arranged so that station No. 1, or the top fiber, always experienced compression upon each succeeding bending part of the pulsating cycle. Both the steel and brass were given six cycles of pulsating bending. After each pulsating cycle was completed, which consisted of bending in one direction and straightening, it required successively higher loads for succeeding test cycles. The initial load was 6870 lb. on the first pulsating bend for the steel and 12,900 lb. were required for the sixth bend. The copper-zinc alloy required 4120 lb. on the first pulsating bend and 5250 lb. on the sixth pulsating bend.

This testing procedure was repeated using similar steel and brass bars annealed, except that the specimens were given cycles of alternate bending. The procedure to be followed in completing a cycle of alternate bending consisted of a first bending and first straightening such that the top fiber at the start experienced compression strain and then zero strain; now a second bending and a second straightening were performed such that outer fibers previously in compression were now in tension and then zero strain upon completion of the second straightening. A pulsating bending cycle consists of one bending and one straightening, whereas a reversed bending cycle consists of two bendings and two straightenings. The reversed bending process was continued until both bars failed in fatigue. The steel bar was bent seven times or $3\frac{1}{4}$ cycles, breaking on the seventh straightening. The brass bar was bent fifteen times or $7\frac{1}{4}$ cycles of reversed bending, breaking on the fifteenth straightening. After every operation of bending and straightening had been completed, it required successively higher loads for each succeeding bending. In the case of the steel, it required 7500 lb. on the first bending in the first cycle and a maximum load of 11,650 lb. on the fifth bending during the third cycle of reversed bending; whereas the brass bar required 5000 lb. on the first bend and 6500 lb. on the fourteenth bending during the seventh cycle of reversed bending.

Figure 4 shows the specimens in various stages of plastic deformation. There was no cumulative increase in gage length on repeated bending and straightening.

Test Results

Typical plots of test data are shown in Figs. 5, 6, 7, and 8 in which true strains and Vickers hardness numbers are indicated corresponding to vertical distances across the beams. These plots made it possible to show a second set of relations, namely, the change in Vickers hardness number *versus* true strains for each pulsating bending (Fig. 9). Finally a third set of relations was plotted of change in Vickers hardness number *versus* cycles of pulsating

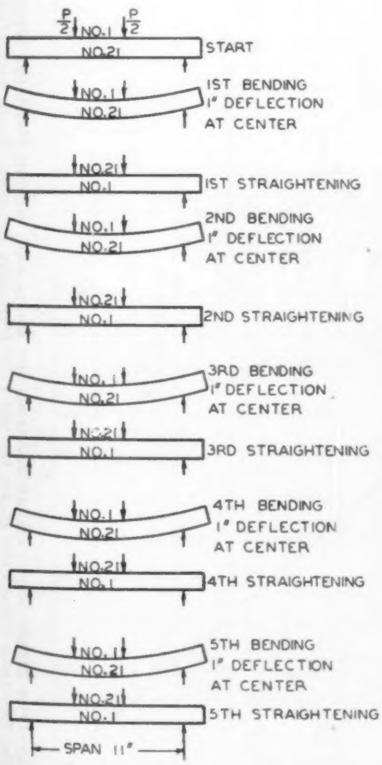
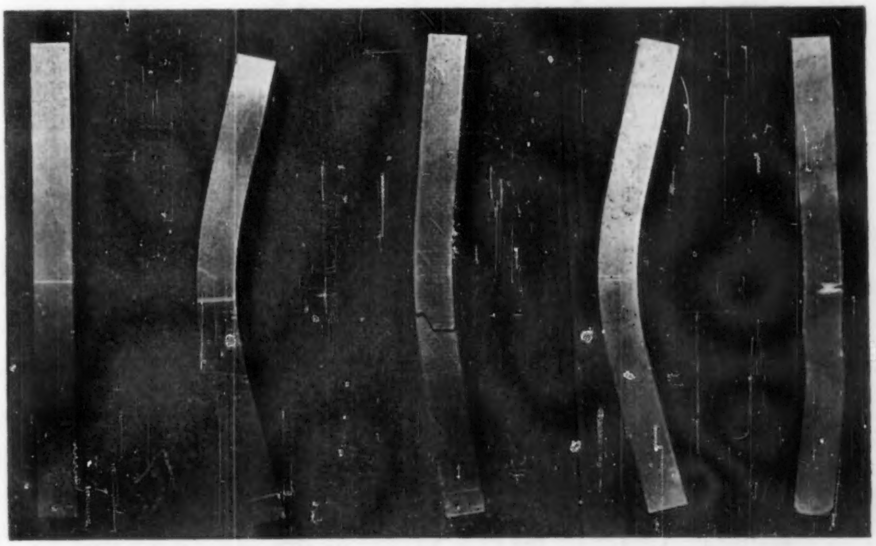


Fig. 3.—Diagram of the Cycles of Pulsating Bending and Straightening.



No. 1	No. 2	No. 3	No. 4	No. 5
Original Form	First Bend	Seventh Bend	First Bend	Fifteenth Bend
S.A.E. 1112	S.A.E. 1112	S.A.E. 1112	Brass	Brass

Fig. 4.—Photographs of the Specimens in Various Phases of Bending.

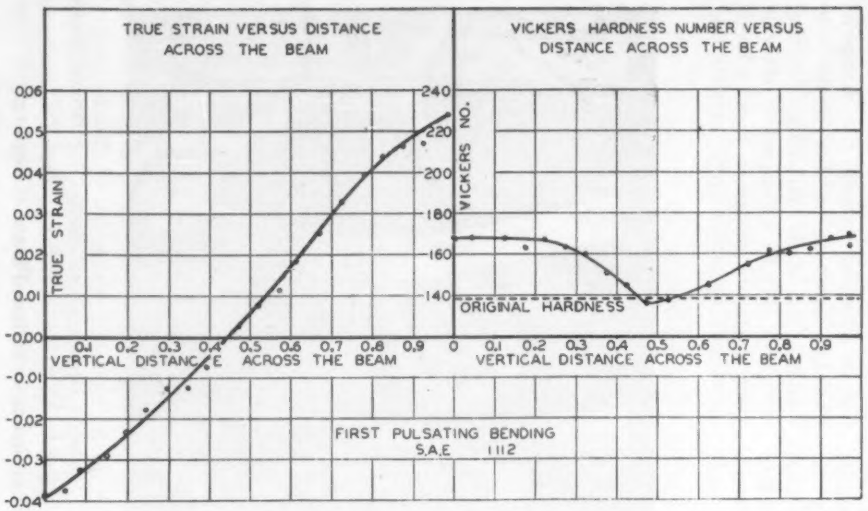


Fig. 5.—True Strain *versus* Distance Across the Beam and Vickers Hardness Number *versus* Distance Across the Beam for the First Pulsating Bending, S.A.E. 1112.

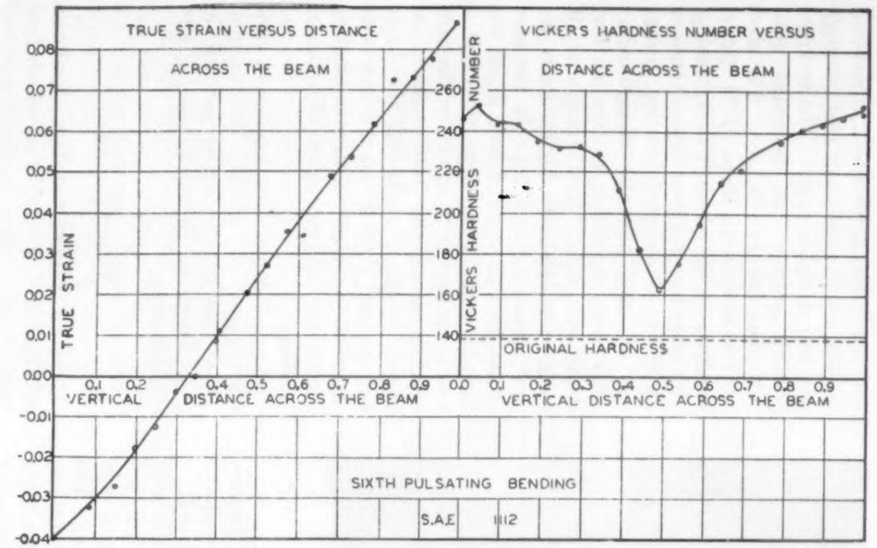


Fig. 6.—True Strain *versus* Distance Across the Beam and Vickers Hardness Number *versus* Distance Across the Beam for the Sixth Pulsating Bending, S.A.E. 1112.

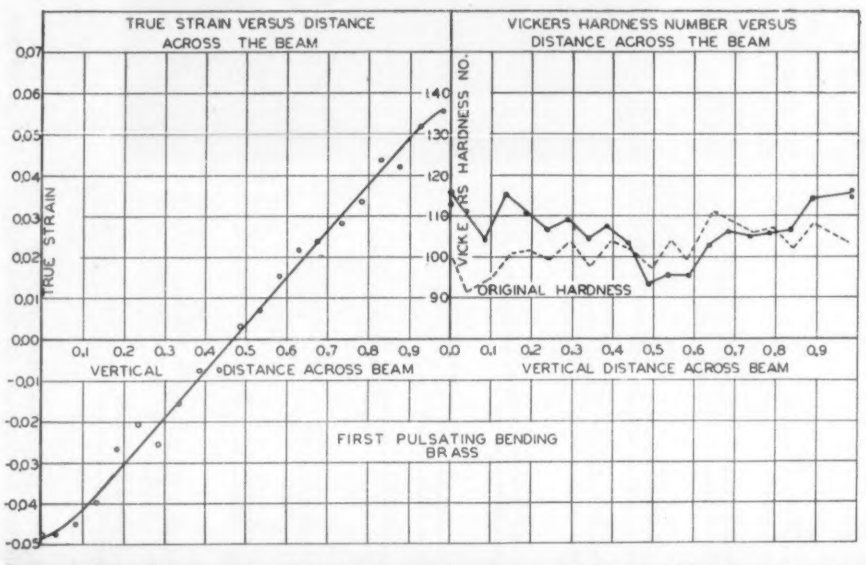


Fig. 7.—True Strain *versus* Distance Across the Beam and Vickers Hardness Number *versus* Distance Across the Beam for the First Pulsating Bending, Brass Annealed.

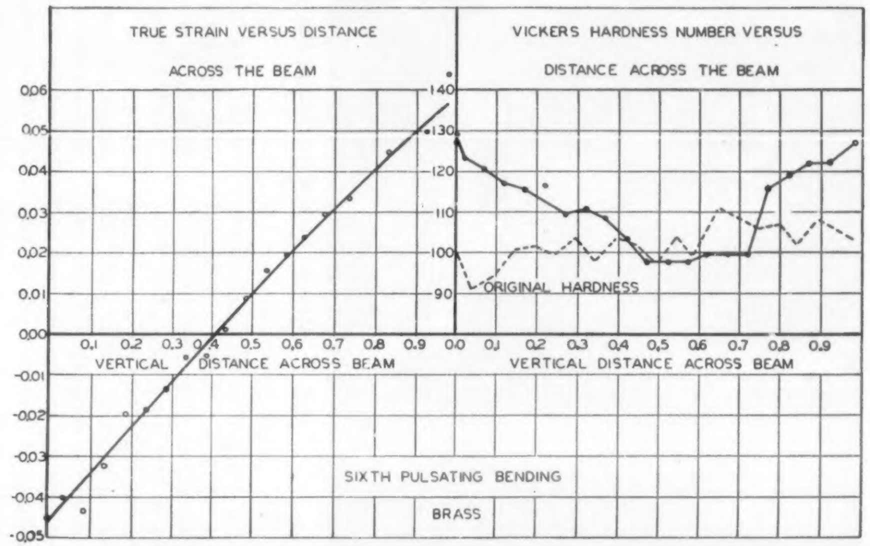


Fig. 8.—True Strain *versus* Distance Across the Beam and Vickers Hardness Number *versus* Distance Across the Beam for the Sixth Pulsating Bending, Brass Annealed.

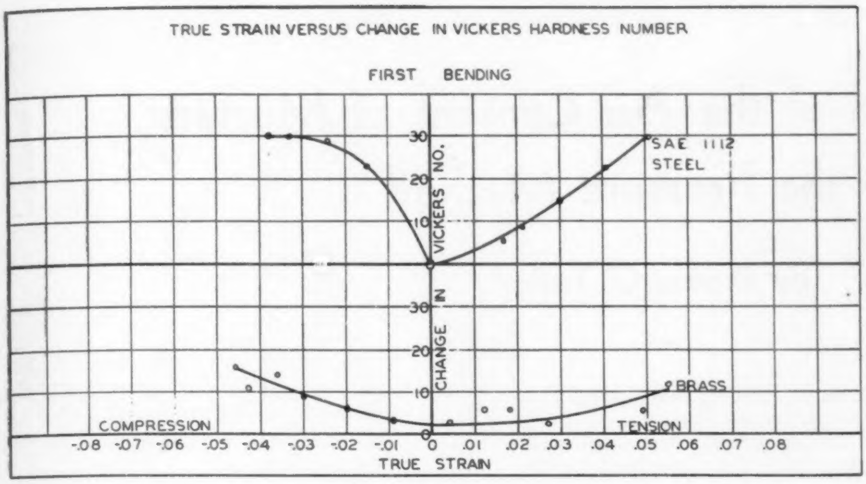


Fig. 9.—True Strain *versus* Change in Vickers Hardness Number for First Pulsating Bending, S.A.E. 1112 and Brass.

bending for various constant true strains indicated in Figs. 10 and 11, in which tensile strains are separated from compression strains. No plots were made for reversed bending.

Summary and Conclusions

The investigation covers a range of true plastic tensile and compressive strains in bending of 0.01 to 0.06 in. per inch. One set of specimens was subjected to pulsating bending cycles while another set of bars was subjected to reversed bending cycles.

Under pulsating bending a distinct trend of hardness change *versus* cycles of bending was evident, both for tension and compression. The S.A.E. 1112 steel is more sensitive to plastic strains and cycles of straining than the copper-zinc alloy. For both materials the rate of change of hardness in compression was greater than in tension.

Because the elements of the beam experience cycles of compression and tension strain during reversed bending, no graphs showing distinct trends could be made but this phase revealed certain conclusions. The steel was more sensitive than the brass to work hardening. A past history of alternate tension and compression strains produces a greater hardness change than a past history of strains of the same sign as in pulsating bending.

Once a fiber is strained plastically and the bending cycle is completed so that the fibers of the beam have zero strain there was no return to the original hardness at room temperature.

Acknowledgment:

The author wishes to express his sincere appreciation to Professor C. W. MacGregor for suggesting this investigation, his guidance and encouragement in this work during the Summer of 1943.

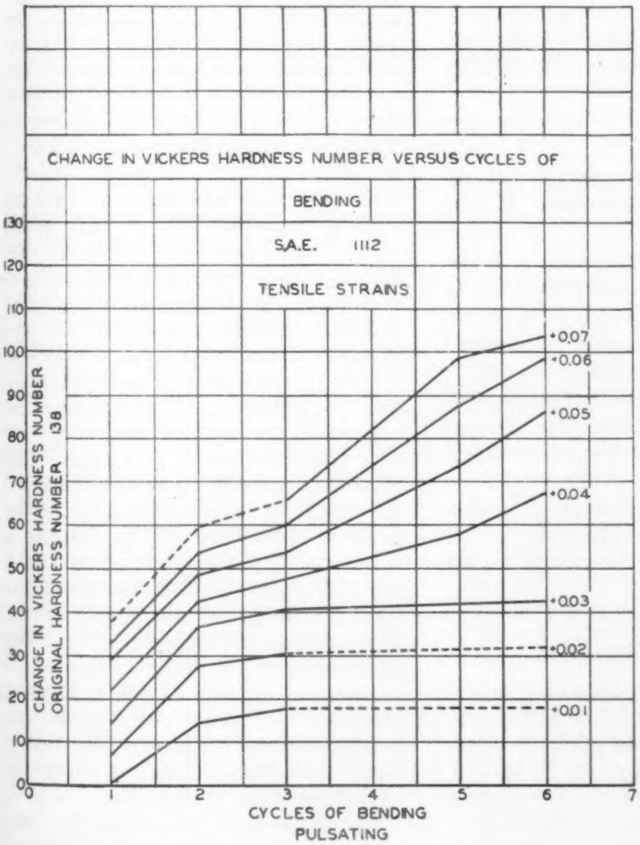


Fig. 10.—Change in Vickers Hardness Number *versus* Cycles of Pulsating Bending for Various Plastic Tensile Strains, S.A.E. 1112 Annealed.

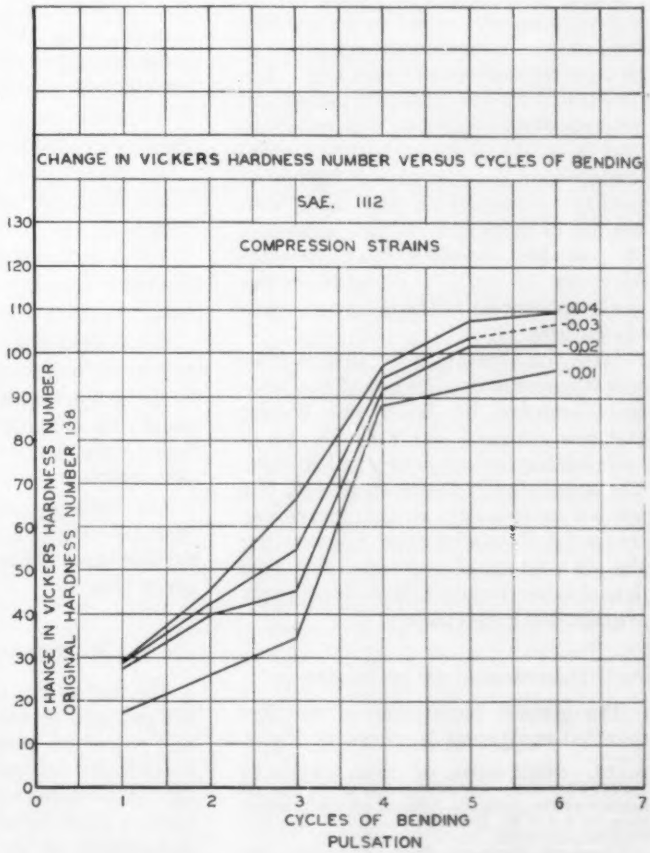


Fig. 11.—Change in Vickers Hardness Number *versus* Cycles of Pulsating Bending for Various Plastic Compression Strains, S.A.E. 1112 Annealed.

Determination of the Air Content of Mortars by the Pressure Method

By Thomas G. Taylor[1]

SYNOPSIS

Pressure apparatus similar to that used in testing concrete has been developed for use in determining the air content of portland-cement mortars. The apparatus is described and some data are presented comparing the results obtained by the pressure method with those obtained by the gravimetric and the displacement methods.

CONSIDERATION of the pressure method for determining the air content of portland-cement mortars was a natural step following the development and use of such equipment for determination of the air content of concrete. While the gravimetric method now in use apparently serves as a satisfactory procedure as set forth in the A.S.T.M. Tentative Method of Test for Air Content of Air-Entraining Portland-Cement Mortar (C 185–47 T),[2] the question was raised as to whether the pressure method might not prove to be an even more satisfactory test. Experience with the pressure method in concrete tests pointed to the possibility that it would prove to be more satisfactory than the gravimetric method in testing commercial mortars made with natural or manufactured fine aggregate of variable porosity and density. Moreover, it would be useful in studies of the air content of the mortar fraction of concretes.

With the above uses in mind, a pressure apparatus making use of the principle proposed by Klein and Walker (1)[3] was designed and built for use in determining the air content of mortar. The apparatus is similar in design, but smaller in capacity, to that developed by Carl A. Menzel for use in measuring the air content of concrete (2). Test data obtained to date with the equipment are reported in this paper.

DESCRIPTION OF APPARATUS

The general appearance of the dismantled equipment is shown in Fig. 1 and an assembly drawing with the principal dimensions of the machined parts is shown in Fig.2.

The apparatus consists of the following three major units:

1. A 500-ml. capacity bowl which can also be used as a unit weight measure for determining the air content of mortar by the gravimetric method,
2. A flanged head unit with assembled stopcock, shielded calibrated glass tube for indicating the air content, pressure gage for indicating the air pressure, and a bicycle pump for supplying air under pressure, and
3. Four clamps for connecting the head unit to the bowl.

Auxiliary pieces of equipment needed for calibration and operation of the unit are:

1. A calibration cup made of brass having a capacity of approximately 80 ml.,
2. A light coil spring for holding the cup in position during calibration, and
3. A light rawhide or plastic headed mallet for tapping the bowl to remove any air trapped in the water above the test sample.

The drawing and photograph of the instrument are self-explanatory so no further explanation of the design will be given here.

METHOD OF OPERATION

The method of operation as given in the paragraphs which follow is a simplified procedure based on the more exact procedure developed by Carl A. Menzel (2). Calculations of certain corrections such as those for effect of differences in distribution of air in the mortar and in the calibration cup and change in volume of air in the calibration cup due to inundation indicate they are small for this 500-ml. capacity meter. They were neglected in the calibration of the instrument for these tests. The expansion factor of the apparatus was also negligible.

Calibration of Instrument:

The apparatus must be calibrated prior to use in determining the air content of mortars. This is done by determining the true volumes of the bowl and calibration cup and the relationship, in per cent, between them. Two No. 24 gage wires are placed on the bottom of the bowl, the calibration cup in the inverted position is then placed on the wires, the spring is placed on top of the cup and the head assembly clamped securely in place on the bowl. The wires provide space for water to enter the cup as the air in the cup compresses under pressure. Water is slowly introduced into the head unit assembly to the zero reading on the scale of the glass tube, trapping the air in the calibration cup. A small air pressure (3 to 4 psi.) is applied to compress the air in the calibration cup and seal the opening with water. The bowl is then tilted at an angle of 45 deg., revolved, and tapped with the mallet several times to remove any air trapped on the sides of the head assembly unit. The pressure is released, the water again brought to the zero mark, and air pressure applied until the percentage of air known to be trapped in the bowl by the calibration cup is indicated on the glass gage. The pressure required to give this indicated air content is read and recorded. The pressure determined in this manner is the "working pressure" to be used with the instrument in all subsequent tests for air content of mortars made at points having the same elevation. The instrument must be recalibrated if moved to a location having a different altitude. Calibration of the instrument should also be checked periodically to eliminate the possibility of errors due to changes in the pressure gage.

The glass tube indicating the percentage of air in the mortar is a ½-in. inside diameter precision bore pyrex glass tube 15¼ in. in length. The tube was graduated by the supplier in tenths

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[2] 1947 Supplement to the A.S.T.M. Book of Standards, Part II, p. 229.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

Fig. 1.—Equipment Used in Determination of Air Content of Mortar by the Pressure Method.

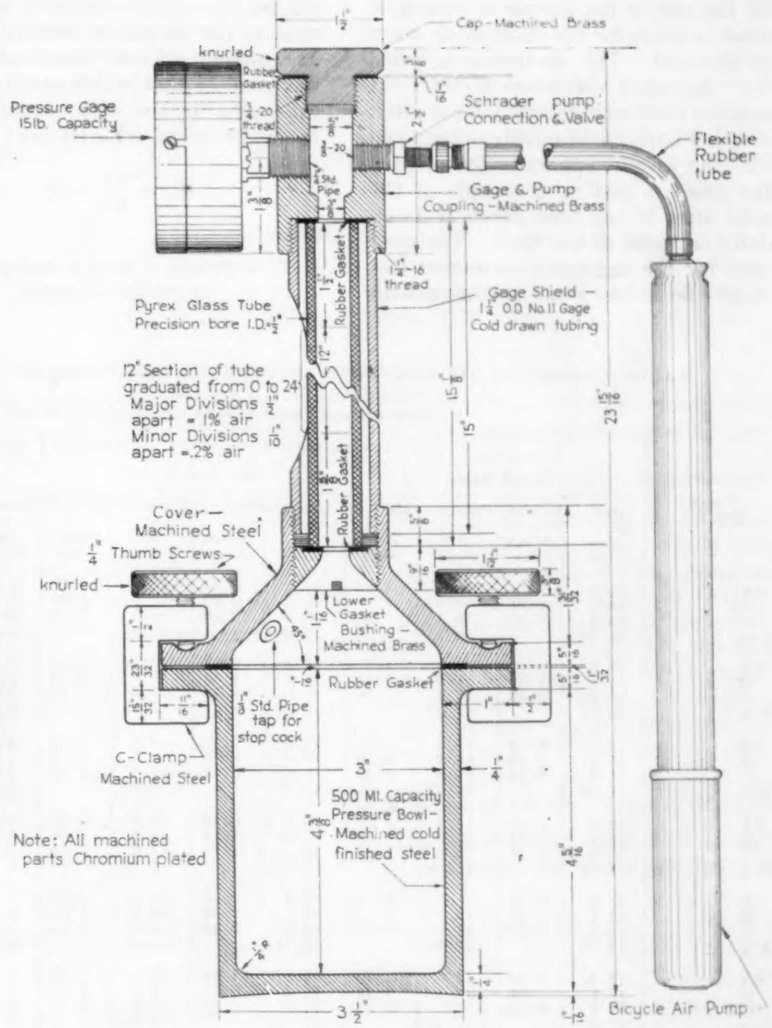


Fig. 2.—Pressure Apparatus for Measurement of Air in Mortar.

of an inch over a 12-in. length of the middle section, each $\frac{1}{10}$ in. representing 0.2 per cent air. The major divisions, every $\frac{1}{2}$ in., are numbered from 0 to 24 to indicate air contents from 0 to 24 per cent. A tube with a $\frac{1}{2}$-in. bore was selected because it most nearly meets the requirements necessary in measuring the air contents encountered in mortars when a 500-ml. sample and an air pressure of approximately 8 psi. are used.

Test Procedure:

The same sample of mortar can be used for determining the air content by both the gravimetric and the pressure methods. It is necessary to know the absorption and specific gravity of the aggregate in order to calculate the air content by the gravimetric method, but this information is not required when determining the air content by the pressure method.

The mortar is placed in the 500-ml. bowl by the standard procedure described in A.S.T.M. Method C 185–47 T.[2] The top surface is then struck off level and the gross weight determined. From this gross weight the net weight of the mortar can be determined for use in computing the air content by the gravimetric method. The head unit is then clamped in position and a small diameter glass tube lowered through the gage glass, from an opening in the top of the gage and pump coupling, until the end is just above the surface of the mortar. Water from an overhead tank is then allowed to flow very slowly through this tube until the head unit is full to the zero mark on the gage glass. Care must be exercised to reduce turbulence which might remove some of the air in the top surface of the mortar sample. A 7-cm. diameter filter paper saturated with water and carefully placed on the top surface before the head unit is clamped in position may be used to protect the mortar surface against removal of air. Next the tube is removed and the entire assembly tilted and rotated slowly while the bowl is being tapped with the mallet to remove any air bubbles adhering to the surfaces above the test sample. The water is brought to the zero mark, the opening at the top closed with a cap, and pressure applied equivalent to that determined in the calibration test. The gross air content, Am_1, is then read on the glass gage and recorded, the pressure released, the instrument tapped several times, and the water level read again (Am_2) while under zero pressure. The difference between the two readings, $Am_1 - Am_2$, is the apparent air content, Am, of the mortar. When the aggregate itself contains a significant amount of air, the apparent air content of the mortar must be corrected by subtracting an aggregate correction factor which is determined as follows:

Aggregate Correction Factor:

Air voids in the sand used in mortar, which are not filled with water during the normal mixing process, respond during the test for air content in the same manner as the entrained air in the mortar. In order to obtain the true

air content of the mortar a correction must be made for the effect of air voids in the sand. This correction is called the "aggregate correction factor." It remains relatively constant for a given material and can be readily determined with the pressure apparatus by applying the pressure test to a sample of the sand after it has been carefully inundated in water in the bowl. The sand used for the aggregate correction test should be in the same condition with respect to moisture content as when it is used in the mortar at time of mixing. The amount of sand tested should be the same as that which would be present during the test of a mortar sample. It may be computed as follows:

$$W_1 = \frac{W_2}{W_3} \times W_4$$

where:

W_1 = weight of sand in mortar sample under test in grams,

W_2 = weight of 500 ml. sample of mortar in grams,

W_3 = weight of total batch of mortar in grams, and

W_4 = weight of total sand in batch of mortar in grams.

A small volume of water is placed in the bowl and the sample of sand, W_1, slowly added while carefully stirring to remove all air trapped between the sand particles. Placing and stirring the sand sample, adding water as necessary

TABLE 1.—MORTAR AIR CONTENTS AND PERCENTAGE VARIATION FROM THE MEAN FOR INDIVIDUAL TESTS.

Cement Ref. No.	Air Contents and Variation from the Mean for Mortars Prepared and Tested as Indicated, per cent															
	1:4 Mortar								1:2.25 Mortar							
	Hand-Mixed				Machine-Mixed				Hand-Mixed				Machine-Mixed			
	Grav. Method		Pressure Method		Grav. Method		Pressure Method		Grav. Method		Pressure Method		Grav. Method		Pressure Method	
	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.	Air Cont.	Mean Var.
1A	19.8	2.06	19.6	1.92	19.1	0.52	19.2	0.68	7.8	0.38	8.4	0.83	9.6	1.03	10.0	1.28
B	18.9	2.58	18.6	3.27	19.2	0.00	18.9	0.89	7.7	1.66	8.4	0.83	9.6	1.03	10.0	1.28
C	19.5	0.51	19.5	1.40	19.3	0.52	19.1	0.16	8.0	2.17	8.6	1.54	9.9	2.06	10.4	2.66
Avg	19.40		19.23		19.20		19.07		7.83		8.47		9.70		10.13	
2A	17.0	1.61	17.3	1.35	17.3	0.17	17.1	1.15	6.2	3.33	7.4	2.35	8.1	1.58	9.2	0.00
B	16.5	1.37	17.0	0.41	17.0	1.56	17.3	0.00	6.0	0.00	7.3	0.97	8.1	1.58	9.0	2.17
C	16.7	0.18	16.9	1.00	17.5	1.33	17.5	1.15	5.8	3.33	7.0	3.18	8.5	3.28	9.4	2.17
Avg	16.73		17.07		17.27		17.30		6.00		7.23		8.23		9.20	
3A	15.5	0.64	15.8	1.06	15.6	0.19	15.6	0.83	4.8	0.63	6.0	1.69	6.6	2.94	7.4	3.02
B	16.1	3.20	16.3	2.06	16.0	2.76	16.3	3.62	4.8	0.63	5.8	1.69	7.0	2.94	7.8	2.23
C	15.2	2.56	15.8	1.06	15.1	3.02	15.3	2.73	4.7	1.47	5.9	0.00	6.8	0.00	7.7	0.92
Avg	15.60		15.97		15.57		15.73		4.77		5.90		6.80		7.63	
4A	14.9	2.21	15.4	1.91	15.3	0.46	15.2	0.85	5.7	4.97	6.8	5.13	7.3	4.74	8.0	0.88
B	15.4	1.14	15.8	0.64	15.7	2.14	15.8	3.06	5.5	1.29	6.2	4.20	6.8	2.44	7.8	1.64
C	15.4	1.14	15.9	1.27	15.1	1.76	15.0	2.15	5.1	6.07	6.4	1.09	6.8	2.44	8.0	0.88
Avg	15.23		15.70		15.37		15.33		5.43		6.47		6.97		7.93	
5A	13.0	0.00	13.3	0.75	13.1	2.58	13.2	1.54	4.6	3.84	5.6	2.38	5.5	0.92	6.4	0.31
B	13.1	0.77	13.5	0.75	13.1	2.58	13.3	2.30	4.4	0.68	5.5	0.55	5.5	0.92	6.4	0.31
C	12.9	0.77	13.4	0.00	12.1	5.25	12.5	3.84	4.3	2.93	5.3	3.11	5.4	0.92	6.3	1.26
Avg	13.00		13.40		12.77		13.00		4.43		5.47		5.45		6.38	
6A	17.8	2.48	17.9	1.70	17.8	1.54	17.9	0.96	6.6	0.46	7.6	0.93	8.1	0.87	9.0	0.78
B	17.1	1.55	17.4	1.14	17.5	0.17	17.6	0.73	6.5	1.07	7.5	0.40	7.9	1.62	8.8	1.46
C	17.2	0.98	17.5	0.57	17.3	1.31	17.7	0.17	6.6	0.46	7.5	0.40	8.1	0.87	9.0	0.78
Avg	17.37		17.60		17.53		17.73		6.57		7.53		8.03		8.93	
7A	17.8	0.00	17.7	1.83	18.2	2.82	17.8	0.56	7.0	4.01	7.9	0.38	9.1	1.45	10.1	0.00
B	17.7	0.56	18.1	0.39	17.1	3.39	17.9	0.00	6.5	3.42	7.7	2.16	9.1	1.45	10.2	0.99
C	17.9	0.56	18.3	1.50	17.8	0.56	18.0	0.56	6.7	0.45	8.0	1.65	8.7	3.01	10.0	0.99
Avg	17.80		18.03		17.70		17.90		6.73		7.87		8.97		10.10	
8A	10.9	0.27	11.1	1.16	10.9	0.27	11.2	1.75	3.7	7.88	4.5	2.98	4.3	0.69	4.8	6.44
B	10.7	2.10	11.2	0.27	11.0	0.64	11.6	1.75	3.3	3.79	4.2	3.89	4.4	1.62	5.3	3.31
C	11.2	2.46	11.4	1.51	10.9	0.27	11.4	0.00	3.3	3.79	4.4	0.69	4.3	0.69	5.3	3.31
Avg	10.93		11.23		10.93		11.40		3.43		4.37		4.33		5.13	
9A	13.4	1.47	13.7	1.65	13.5	0.52	13.7	0.00	4.4	0.00	5.3	1.34	6.1	0.00	6.8	1.02
B	13.8	1.47	14.2	1.94	13.6	0.22	13.6	0.73	4.4	0.00	5.3	1.34	6.2	1.64	7.0	1.89
C	13.6	0.00	13.9	0.22	13.6	0.22	13.8	0.73	4.4	0.00	5.1	2.48	6.0	1.64	6.8	1.02
Avg	13.60		13.93		13.57		13.70		4.40		5.23		6.10		6.87	
10A	13.2	2.22	13.9	0.93	13.4	0.52	13.5	0.95	5.2	2.56	6.2	1.64	6.6	0.46	7.4	0.00
B	13.9	2.96	14.3	1.92	13.1	2.75	13.4	1.69	5.0	1.38	6.1	0.00	6.5	1.07	7.4	0.00
C	13.4	0.74	13.9	0.93	13.9	3.19	14.0	2.71	5.0	1.38	6.0	1.64	6.6	0.46	7.4	0.00
Avg	13.50		14.03		13.47		13.63		5.07		6.10		6.57		7.40	
11A	16.1	1.07	16.3	0.18	16.2	0.81	16.4	0.43	5.5	0.55	6.7	0.45	6.8	2.44	7.9	1.25
B	15.8	0.82	16.3	0.18	16.5	2.68	16.8	2.88	5.4	1.28	6.6	1.05	7.2	3.30	8.4	5.00
C	15.9	0.19	16.2	0.43	15.5	3.54	15.8	3.24	5.5	0.55	6.7	0.45	6.9	1.01	7.7	3.75
Avg	15.93		16.27		16.07		16.33		5.47		6.67		6.97		8.00	
12A	16.8	0.18	16.7	1.36	17.0	0.00	17.1	1.60	5.8	0.00	6.8	0.00	8.1	0.00	9.3	1.09
B	16.5	1.96	16.8	0.77	17.3	1.76	17.0	1.01	5.8	0.00	6.8	0.00	8.3	2.47	9.4	2.18
C	17.2	2.20	17.3	2.24	16.7	1.76	16.4	2.55	5.8	0.00	6.8	0.00	7.9	2.47	8.9	3.26
Avg	16.83		16.93		17.00		16.83		5.80		6.80		8.10		9.20	
13A	14.5	1.56	14.7	1.54	14.7	1.54	14.9	1.52	5.1	2.48	5.9	2.80	6.8	0.00	7.6	0.93
B	15.1	2.51	15.4	3.14	15.1	1.14	15.5	2.44	5.2	0.57	6.1	0.49	7.0	2.94	7.8	3.58
C	14.6	0.88	14.7	1.54	15.0	0.47	15.0	0.86	5.4	3.25	6.2	2.14	6.6	2.94	7.2	4.38
Avg	14.73		14.93		14.93		15.13		5.23		6.07		6.80		7.53	
14A	17.0	0.76	17.1	1.33	17.4	1.14	17.9	0.39	5.5	6.78	6.7	5.64	9.0	1.10	10.0	1.96
B	17.2	0.41	17.7	2.14	17.8	1.14	18.2	1.28	5.8	1.70	7.1	0.00	9.3	2.20	10.5	2.94
C	17.2	0.41	17.2	0.75	17.6	0.00	17.8	0.95	6.4	8.48	7.5	5.64	9.0	1.10	10.1	0.98
Avg	17.13		17.33		17.60		17.97		5.90		7.10		9.10		10.20	
15A	16.1	1.43	15.9	1.85	16.9	0.18	16.6	1.19	5.5	3.51	6.3	2.02	8.0	0.87	8.7	1.14
B	16.3	0.19	16.4	1.23	16.5	2.54	16.7	0.60	5.8	1.75	6.6	2.64	8.2	1.61	8.9	1.14
C	16.6	1.68	16.3	0.62	17.4	2.77	17.1	1.78	5.8	1.75	6.4	0.47	8.C	0.87	8.8	0.00
Avg	16.33		16.20		16.93		16.80		5.70		6.43		8.07		8.8	
Grand Avg. Mean Var., per cent		1.26		1.24		1.44		1.36		2.15		1.67		1.58		1.67

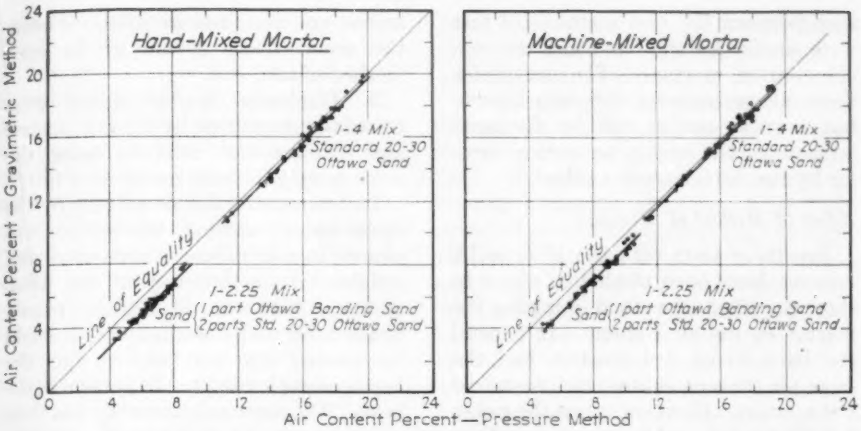


Fig. 3.—Relationships Between Air Contents of Mortars Determined by Gravimetric and Pressure Methods.

NOTE.—Each plotted point represents one of three tests made with each of 15 type IA cements.

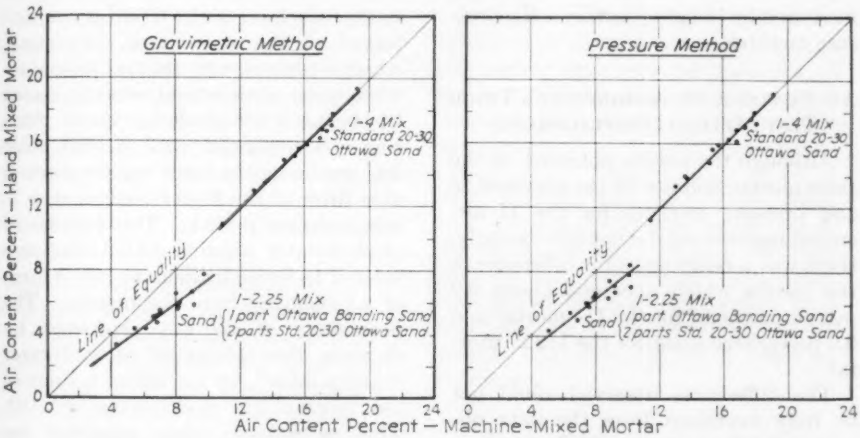
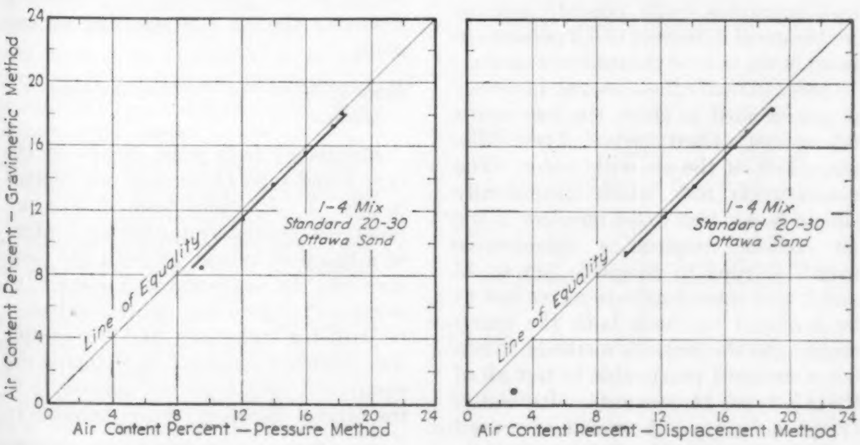


Fig. 4.—Relationships Between Air Content of Hand and Machine-Mixed Mortars.

NOTE.—Each plotted point represents the average of three tests made on each of 15 type IA cements.



(a) Determined by gravimetric and pressure methods.

(b) Determined by gravimetric and displacement methods.

Fig. 5.—Relationship Between Air Contents of Mortars.

NOTE.—Each plotted point represents one test of a blend of a type I and type IA cement.

to keep it inundated, should cover a period having the same duration as that required to mix and place a sample of mortar in the bowl ready for test. When all the sand has been placed in the bowl, the head assembly of the pressure apparatus is clamped in position on the bowl and the test procedure carried through in the manner described above for a sample of mortar. Similarly, as discussed above for mortar, the aggregate correction factor, As, is computed as follows:

$$As = As_1 - As_2$$

where:

As_1 = reading under the operating pressure, and

As_2 = reading after pressure is released.

Owing to the uniformly low absorption and uniform composition and gradation of the particles, the aggregate correction factor for standard Ottawa sand is so small that it may be neglected. However, the aggregate correction factor should be determined for all sands, and, if necessary, proper corrections should be made in the mortar test results.

Calculation of Net Air Content of Mortar:

The entrained air content of mortar by the pressure method is calculated as follows:

$$A = Am - As$$

where:

A = entrained air content, percentage by volume of mortar,

Am = apparent air content, percentage by volume of mortar, and

As = aggregate correction factor, percentage by volume of mortar.

Air Contents Determined by the Pressure and Gravimetric Methods

The first series of tests made with the 500-ml. capacity air indicator was designed to study the characteristics of the apparatus and to determine the relationship between the air content of mortars by the gravimetric and pressure methods. Fifteen commercial type IA cements were used in these tests. The mortars used were as follows:

(1) 1:4 standard Ottawa sand mortar mixed in accordance with C 185–47 T,

(2) 1:2.25 blended Ottawa sand mortar mixed by the procedure outlined in C 185–47 T,

(3) 1:4 standard Ottawa sand mortar mixed with a mechanical mixer, and

(4) 1:2.25 blended Ottawa sand mortar mixed with a mechanical mixer.

Three tests, each on a different day, were made with each of the fifteen cements for each of the four conditions listed above.

The blended Ottawa sand consisted of 1 part Ottawa banding sand[4] and 2 parts standard Ottawa No. 20 to 30 sand. The rich mix of 1 part cement and 2.25 parts sand was used because it had been suggested (3) as a combination which, when used with the blended sand, would give air contents more in line with those obtained in tests of concrete.

The mechanical mixer used in the tests was a Hobart Model No. N-50, 5-qt. capacity food mixer, with a specially designed mixing paddle. The mechanical mixing procedure was as follows: Water and cement were mixed at low speed for 30 sec.; mixing at low speed was continued while the sand was slowly added over the second 30-sec. period; the mixer was stopped, shifted to intermediate speed, and mixing continued for another 30 sec.; mixer was stopped and mixing bowl covered with a damp cloth for 1½ min.; at end of this period the mixer was started at the intermediate speed and mixing continued for 1 min.

Test results reported in Table I have been plotted in Figs. 3 and 4 to show the relationships between the air contents determined by the gravimetric and pressure methods of 1:4 standard Ottawa sand mortar and 1:2.25 blended Ottawa sand mortar for hand mixing and machine mixing (Fig. 3), and relationships between the air contents of hand-mixed and machine-mixed mortars determined by the gravimetric and the pressure methods for 1:4 standard sand mortar and 1:2.25 blended sand mortar.

Effect of Method of Test:

Results of tests with the 15 type IA cements indicate that the values for air content of mortar determined by the pressure method are slightly higher than those obtained by the gravimetric method of test, Fig. 3. For the 1:4 mix the difference in air contents averaged about 0.2 percentage points[5] and was fairly constant over the wide range of air contents represented (11 to 20 per cent). For the 1:2.25 mix, the difference in air contents was somewhat greater, averaging about 0.9 percentage point higher for the pressure method. Here again the difference was generally constant over the range of air contents represented. The differences in air content between the two methods of test were similar for the hand and the machine-mixed mortars. The reason for these differences is not definitely known, but possible causes will be discussed later under the section on tests of mortar by the displacement method.

Effect of Method of Mixing:

Results of tests with the 15 type IA cements have been plotted in Fig. 4 to show the effect of method of mixing the mortar on the air content. In general the hand-mixed 1:4 mortars had the same air content as the machine-mixed 1:4 mortars. However, when the richer 1:2.25 blended sand mortar was used the air contents of the machine-mixed mortars were always higher than corresponding hand-mixed mortars, and the difference appeared to be roughly proportional to the quantity of air in the mortar. Similar results were obtained regardless of whether the air content was measured by the gravimetric or the pressure methods.

Air Contents Determined by a Third Test Method (Displacement)

Although the results obtained on the same mortar samples by the gravimetric and pressure methods for the 15 air-entraining cements did not differ greatly, there was a fairly constant difference in the results which averaged about 0.2 percentage point for the 1:4 mortar and 0.9 percentage point for the 1:2.25 mortar.

The differences observed could not be fully explained from the data obtained in these tests. Differences in specific gravity and sampling errors which might affect the calculated results of the gravimetric test combined with the accumulative effect of small corrections which were considered too small to be significant in calibration of the pressure apparatus could possibly account for the small difference of 0.2 percentage point in the tests of the standard mortar. In order to verify these results, however, it was decided to check the two methods against a third method of test—displacement of the air with water. The displacement test, which theoretically should be another exact measure of the air content, requires a considerable length of time to complete (up to 45 min.), and since duplicate mixes had to be prepared to check both the gravimetric and the pressure methods, it was not considered practicable to test all of the 15 type IA cements. Instead a type I and a type IA cement were used individually and blended to give six mortars having a wide range of air contents. These were tested as follows:

1. One 1:4 mortar mix of each blend was tested for air content by the gravimetric and the pressure methods using the same sample of mortar for each method of test, and

2. Duplicate mortar mixes were tested for air content by the gravimetric and displacement methods using the same sample for both methods of test.

In determining the air content by the displacement method, the sample was placed in the pressure apparatus and weight data determined in the usual manner. A stirring paddle was so placed in the head unit assembly that it could be lowered into and used to mix the mortar sample from top to bottom in the bowl. The head unit assembly was then secured to the bowl and water added to the zero mark before the stirring paddle was lowered into the test sample. The sample was stirred thoroughly so that the air in the mortar was worked out and replaced by the water. In turn the air thus removed was replaced with a mixture of 50 per cent water and alcohol so that the level of the liquid was maintained at the zero mark. Foaming, which interferes with the test procedure when water alone is used, was eliminated by the use of the alcohol mixture. Stirring was continued until an end point was reached when there was no appreciable drop in the liquid level over a 2-min. stirring period. The volume of alcohol-water solution added was considered to be equivalent to the volume of air removed from the mortar. The percentage of air was computed by dividing the volume of alcohol-water solution added, by the initial volume of the mortar and multiplying by 100. This percentage, when corrected for compressibility of the head of water, was the air content determined by the displacement method.[6]

The procedure described above was not practical for determining the air content of 1:2.25 blended sand mortar owing to the difficulty of completely removing the air and reaching an end point.

Tests of Mortar by the Displacement Method:

Results of tests with blends of the type I and type IA cements are plotted in Fig. 5. In these tests it was not practicable to determine the air content of a batch of mortar by both the pressure and the displacement methods because part of the same equipment had to be used for both tests, and the sample was disturbed too much in changing the equipment over from one procedure to the other. However, it was possible to

[4] Ottawa silica sand graded 98 per cent passing the No. 50 sieve, 24 per cent passing the No. 100 sieve, and 1 per cent passing the No. 200 sieve.

[5] In this paper the air content of mortar is given in per cent of the total volume of mortar (inclusive of the entrained air) in the sample tested. In making comparisons, the arithmetic differences between these percentages are called percentage points. This terminology avoids the possibility of interpreting the percentages incorrectly.

[6] For a discussion of the factors which affect the displacement (rolling) and pressure methods of measuring entrained air in concrete, see "Procedures for Determining the Air Content of Freshly-Mixed Concrete by the Rolling and Pressure Methods," by Carl A. Menzel, *Proceedings*, Am. Soc. Testing Mats., Vol. 47, p. 833 (1947).

make the gravimetric test on the same sample of mortar that was used for the displacement test or the pressure test. Since batches prepared in an identical manner varied slightly in air content, the air contents determined by the pressure and displacement methods on different batches are not directly comparable. Therefore air contents obtained by each of these two methods are plotted against the results obtained by the gravimetric method which is directly comparable since, in each case, it was made on the same mortar sample. Comparison of air contents obtained by the pressure and displacement methods with those obtained by the gravimetric method indicates the agreement which might be expected between these two methods of tests.

In Fig. 5 the air contents of 1:4 mortar by the gravimetric method have been plotted against the air contents determined by the pressure method and by displacement. It will be noted that the air contents, which varied over the wide range of 9 to 18 per cent, were generally somewhat lower for the gravimetric than for either of the other methods of test. The differences for the six air contents represented averaged 0.47 percentage point for the pressure method and 0.48 for the displacement method.

Although the pressure and displacement methods were not made on identical samples, the similarity in the relationships shown by each of these two methods of test and the gravimetric method indicates that they will give about the same results, subject to the normal variations common to each method. The gravimetric method of test appears to give air contents which are slightly lower than those obtained by the other two methods. There are several factors which may cause the difference in values obtained by these methods. It is not the purpose of this paper to analyze each method of test, but it is believed that the following factors may have contributed to the differences reported above:

1. Use of a specific gravity of 3.15 for all cements in gravimetric calculations instead of the true specific gravities. The specific gravity of cement determined in water rather than in kerosine would probably more nearly approach actual conditions of test. If this specific gravity had been used for the 15 type I cements discussed previously, the average specific gravity used in the gravimetric calculations would have been 3.184 instead of 3.150. This would have resulted in gravimetric air contents which would have been, on the average, 0.140 percentage point higher for the 1:4 mortar tests and 0.214 percentage point higher for the 1:2.25 mortar tests than the values reported for the standard A.S.T.M. procedure.

2. Gravimetric calculations assume the sample tested truly represents the mortar mix as originally proportioned. Loss of water through evaporation, coating of surface of mixing bowl and settlement to bottom of mix may change the actual sample from the conditions assumed. Any and all errors either in assumed properties of materials, fabrication of the batch, testing and calculations affect the final calculation of the air content. These errors may be cumulative or compensating depending upon conditions, and, in general, would be likely to affect the air content values determined by the gravimetric method more than those determined by the pressure and displacement methods. The latter methods attempt to measure the air content of the mortar directly as sampled.

3. It has been suggested (**4**) that the difference in air contents shown by the gravimetric and pressure methods of test may be due to absorption of some of the air by the water used in the pressure test resulting in air content values which are too high. The solubility of air in water increases with the pressure. However, in view of the close agreement of the results obtained by the few tests made by the pressure and the displacement test methods, it would appear that the absorption of air in the water under pressure had an insignificant effect on the results.

Reproducibility of Results

The average percentage variation from the mean for the individual tests of the 15 type IA cements were computed in an effort to determine which of the methods of test could be expected to give the most consistent test data. Results of these calculations follow:

Method of Mixing	Average Variation from the Mean, per cent	
	Gravimetric Method	Pressure Method
1:4 Standard Ottawa Sand Mortar		
Hand	1.26	1.24
Machine	1.44	1.36
Average	1.35	1.30
1:2.25 Blended Ottawa Sand Mortar		
Hand	2.15	1.67
Machine	1.58	1.67
Average	1.86	1.67

For the 1:4 mix the hand-mixed mortar gave the lowest percentage variation. However, the difference was not great. For the 1:2.25 mix, the percentage variation from the mean was lowest for the machine-mixed mortar. For three out of the four conditions of test the pressure method gave slightly lower variations than the gravimetric method of test. It is believed, however, that any of the methods tried could be used satisfactorily as a measure of control of the air content of mortars made with Ottawa sand.

Although, as shown previously, the A.S.T.M. standard gravimetric test gave air content values which were consistently lower than those obtained by other tests, it is believed that the test results obtained by this method are, for all practical purposes, as reproducible as those obtained by other methods. This reproducibility is believed to be due to the uniform composition and gradation and low absorption properties of the standard Ottawa silica sand used as aggregate. No data are available to indicate whether the same degree of reproducibility of results would be obtained if sands made up of particles nonuniform in composition and having variable absorption and specific gravity properties were used.

Since the pressure method of test takes somewhat longer to complete (approximately 3 to 5 min. more than the gravimetric method), the small difference in air contents and degree of reproducibility does not warrant recommending it as a substitute for the present tentative gravimetric method for determining the air content of 1:4 mortar (A.S.T.M. Tentative Method C 185-47 T). With the establishment of proper limits, it is believed that the gravimetric method will give as good results in controlling cement manufacture and acceptance as the other methods reported here. However, on the other hand, if mortars made with other types of sands containing particles of variable composition, density, and absorption are to be studied, it is believed that the pressure method will be the most suitable, since by its use, it is not necessary to make separate determinations for specific gravity and absorption on the materials used in the mix.

It should be understood that the above endorsement of the gravimetric test is intended only for the determination of air content in accordance with the A.S.T.M. Tentative Method of Test for Mortar (C 185–47 T). The pressure method of test is recommended for use with mortars made with other types of sands and particularly for tests of mortars and concretes in the field. Even under well-controlled conditions in the laboratory, the gravimetric method of test for the air content of concrete has, on several occasions, given negative values. Repeat tests on the same mix on a different day have in some instances also given negative results. The reason for these negative values, which are

theoretically impossible, has not been positively determined. In the field, where control over materials and all operations of the batching, mixing and placing must, of necessity, be less exact than in the laboratory, the pressure method of test is much more reliable than the gravimetric method. Factors which may affect the gravimetric method have been discussed briefly under the section on tests of mortar by the displacement method.

Summary and Conclusions

The construction and operation of a pressure air indicator for determining the air content of portland-cement mortars has been described. The results of tests made with the apparatus may be summarized as follows:

1. For mortars mixed according to the procedure described in A.S.T.M. Tentative Method C 185–47 T, the air contents determined by the gravimetric method are slightly lower than those determined by the pressure method, the difference being about 0.2 percentage point for 1:4 standard Ottawa sand mortar and about 0.9 percentage point for a 1:2.25 blended Ottawa sand mortar. Values obtained by the displacement method are in good agreement with those obtained by the pressure method.

2. With 1:4 standard Ottawa sand mortar, machine mixing gave the same air contents as hand mixing.

3. When a 1:2.25 blended Ottawa sand mortar was used, machine mixing gave higher air contents than hand mixing; the difference in air content increased as the air content of the mortar increased.

4. The air content of 1:2.25 blended Ottawa sand mortar was approximately $\frac{1}{3}$ to $\frac{1}{2}$ of that of the 1:4 standard sand mortar. So far as the reproducibility of results is concerned, no advantage would be gained by using the 1:2.25 mortar instead of the 1:4 standard Ottawa sand mortar.

5. With standard Ottawa sand, having uniform particles of low absorption, the air contents determined by the gravimetric method are only slightly lower than those determined by the pressure method, and the difference remains fairly constant over a wide range of air contents. In view of this and because the gravimetric method is more rapid, it appears that the current A.S.-T.M. Tentative Method C 185 - 47 T method is adequate for the purpose intended.

6. The pressure air indicator (the use of which does not require separate determinations for specific gravity and absorption of the aggregates) should be useful for determining the air content of mortars made with commercial fine aggregates of variable composition and porosity, or for determining the air content of the mortar fraction of concrete mixtures.

Acknowledgment:

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Theories of Adhesion as Applied to the Adhesive Properties of High Polymers[1]

By Charles J. Seiler[2] and A. D. McLaren[3]

Within the last eight to ten years the adhesives field has been passing through a transition period. Older methods of "try everything" are being superseded by efforts based on "theories of adhesion." While it is true that many contradictions still exist, more and more tailor-made adhesives are reaching the market—a market, incidentally, of almost unlimited extent when one considers, for example, the utility of adhesives in aircraft and prefabricated home construction.

From the work of McBain and coworkers (1)[4] and of Browne and Truax (2) adhesion has come to be regarded as a consequence of the action of two phenomena: that of specific adhesion, which is produced by molecular forces of the same magnitude as those responsible for the cohesion of the different atomic and molecular units of all matter, and mechanical adhesion, which consists in the keying of the adhesive around fibers and into crevices of the materials joined. Adequate forces of cohesion must also be present to prevent tensile failure within the body of the adhesive. Otherwise, any attempted measurement of adhesion degenerates into a measurement of cohesion instead.

Grouping of factors contributing to adhesion into one or the other of these categories is somewhat arbitrary. Weyl (3), for example, defines forces of polarity in glued joints in terms of specific adhesion factors whereas Delmonte (4) and McLaren and Hofrichter (5) include polar effects in a nonspecific grouping. Polarity may logically be considered to be a requisite for both types of adhesion, since it is first necessary for an adhesive to wet a surface before good mechanical or chemical bonds can be formed. After wetting and solidification, the forces of polarity existing at the interface may then serve to prevent bond failure.

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[1] From the M.S. Thesis of C. J. Seiler, 1948, at the Polytechnic Institute of Brooklyn, N. Y.

[2] Bakelite Corp., Bloomfield, N. J. Presented at the Committee D-14 Meeting on Adhesives in Washington, March 4, 1948.

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[4] The boldface numbers in parentheses refer to the list of references appended to this paper.

Bikerman (6) (conversely) admits the utility of polar forces in bringing an adhesive into close contact with a surface but denies that they contribute a great deal to preventing bond failure. He ascribes the ultimate strengths of joints to rheological forces involving tackiness and a viscosity range. At the present time the relative contributions of the various specific and mechanical factors to joint strength is debatable. The tendency, however, has been to ascribe the greater part of adhesive strength to specific factors.

Factors Influencing Adhesion

Although proper understanding of mechanical factors involved in "adhesion" will give the best possible joint for any adhesive, these forces can account for only a part of the variations in the strengths of joints obtained for different adhesives.

Specific Factors:

The "chemical" factors influencing adhesion comprise the various cohesive forces which hold all matter together. Four general types of bonds have been recognized: electrostatic, covalent (including hydrogen bonding and chelate bonding), metallic, and the residual bonding forces, commonly known as van der Waals forces. Rinker and Kline (7) have included an excellent review on intermolecular and interatomic forces in their survey of adhesion.

Lennard-Jones and Dent (8) show from a study of crystalline systems that electrostatic bonds between ions represent the strongest bonding forces available for adhesion. However, these forces fall off extremely rapidly with distance from the plane of the crystals. Van der Waals forces on the other hand, fall off according to an inverse second or third power of the distance. The result would suggest that the van der Waals forces act as the first agents in the process of adsorption of atoms and ions to bring them into a range where electrostatic or covalent forces may prevail. Soldered or welded joints have been cited to illustrate the great strengths obtained when "chemical" forces apply (9). The bonding of rubber to metal also involves in some instances primary sulfur bridges between metallic atoms and rubber molecular chains.

Herman Mark (10) from his studies of the chemical and physical properties of cellulose suggests that a large part of the strength of adhesive bonds to cellulose results from hydrogen bonding forces, in cases, such as phenolic resins and some of the vinyl polymers, where the adhesive contains large concentrations of chemical groups capable of so reacting.

Recent work by several investigators has demonstrated that secondary forces alone may be sufficient to account for the strengths of the majority of glued joints. These secondary forces involve (*a*) dipole-dipole attraction forces, or orientation forces; (*b*) induced dipole-dipole attractions which result from the presence of a permanent dipole in close proximity to a material having an electronic structure capable of induced intramolecular orientation; and (*c*) dispersion forces arising from the interactions occurring between electronic systems regardless of the presence of permanent or induced dipoles. According to De Bruyne (11) the orientation and dispersion forces predominate in determining the character of the bond. Orientation forces partially account for the sticking of hydrophilic adhesives to hydrophilic surfaces (that is, phenolic resins to wood) while dispersion forces account for the adhesion of hydrophobic adhesives to nonpolar surfaces (polystyrene or rubber to metal). De Bruyne (12) sums this up with the statement that "strong joints can never be made to polar adherends with nonpolar adhesives, or to nonpolar adherends with polar adhesives." Nonpolar adhesives, since they rely mainly on comparatively weak dispersion forces, will be inferior in strength to hydrophilic adhesives, which possess high concentrations of strong dipoles. Exception to this rule has been recently taken, however (13). From a study of the effect of increasing carboxyl concentration on adhesion to cellulose of an isoviscous series of vinyl chloride-vinyl acetate-maleic acid copolymers it has been found that a plot of the log of adhesion *versus* the log of the carboxyl concentration gave a straight line (14). Analysis shows that these data conform to an equation of the type

$$\text{Adhesion} = K\,(\text{COOH})^n$$

similar to the Freundlich adsorption isotherm which was derived from measurements involving the adsorption of pure compounds such as acetic and benzoic acid by charcoal. Within the range 20 to 50 C. the exponent is reasonably close to the theoretical value of 0.67 which was predicted by Gyani (15) for surface sorption. These measurements have been interpreted to mean that adhesion is the resultant of competition between two separate energies, namely, an energy of cohesion within the adhesive, and an energy of sorption (16). The former energy is greater than the latter which results in an increase in adhesion with increasing temperature. Recent work (17) has shown that the same type of curves are obtained when aluminum (probably partially covered by oxide coating) is substituted for cellulose as the adherend. Adhesion curves for carbonyl-containing polymers (styrene-methyl vinyl ketone and vinyl acetate-methyl vinyl ketone), on the other hand, do not show this trend in adhesion with increasing carbonyl group concentration. Adhesion is low and near that of polystyrene or polyvinyl acetate until the mole fraction of ketone is above 0.8. Above 0.8 adhesion increases rapidly toward the value characteristic of polyvinyl ketone. This can be partly explained by an increase in polarity and partly by a decrease in cohesive energy density.

Recently a correlation has been worked out for adhesion of polymers to cellulose with tack temperature (temperature at which polymer systems have equal fluidity) and dielectric constants of polymers and dipole moments of polymer polar substituents (16). From a study of the adhesion to cellulose and modified cellulose of a large number of polymers containing various chemical groups (CN, Cl, NO_2, CH_3, etc.) and correlation of these data with the measured dipole moments of these groups, it has been shown that adhesion between polar groups is specific and that if two dipoles are of quite divergent magnitude dipolar attraction between coating and substrates is less pronounced than if they are roughly of the same value.

In order for the adsorptive forces, which are assumed to be measures of dipole-dipole bonds, to function properly, the adhesive must have certain viscosity characteristics. Mark (18) has defined the optimal viscosity range for high polymers in terms of a degree of polymerization of 50 to 300. If degree of polymerization is too low, poor adhesion results through chain slippage; if too high, the viscosity is too great and the material is tough and hard. An abrupt decrease in adhesion below the second order transition point of polymers has been shown to occur (13).

Nonspecific Factors:

These are concerned primarily with getting the adhesive into close proximity to the surfaces to be bonded. According to Bikerman (6) they are the main contributing factors to the strengths of joints. Here we must be clear in recognizing that Bikerman is referring to cohesive failure and not adhesion failure. His use of the term adhesion is not rigorous.

Several other fundamental approaches to the determination of the nature of adhesion have been made. Bartell and coworkers (19) have studied the angle formed by a drop of liquid on a flat surface (contact angle) assuming this to be a measure of surface attraction (that is, the angle of contact diminishes as adhesion increases). Harkins and Boyd

(20) have devised a calorimetric method for measuring the heat of wetting when a solid is immersed in a liquid. The heat liberated is directly related to the energy of attraction between the two substances. Palmer and Rideal (21) have pointed out that the orientation of soap molecules, which depends on molecular properties, is a very important phase of wetting and detergency.

All adhesives must have tack at some time during application in order to form a strong bond. Formation of the bond can then be accomplished by one of the following methods:

(*a*) Use of heat to provide tack, followed by cooling,

(*b*) Application of adhesive in a solution followed by solvent evaporation,

(*c*) Use of pressure to exceed yield point (liquid-solid transition) and force adhesive to bond followed by release of pressure, or

(*d*) Chemical reaction after application of the adhesive.

According to Delmonte (4), the ideal combination for a good polymer adhesive should be possible with an intermediate degree of polymzerization for specific adhesion and components of high molecular weight for best cohesive strength. The molecular degradation resulting from the process of cyclizing natural rubber leads to an adhesive with better properties. Since thermoplastic adhesives are polymerized before application they require more judicious selection of their molecular weight ranges than thermosetting polymers.

The strength of a bond after an adhesive has set depends on the presence of an optimal modulus of elasticity, which reflects on the ability of the glue to absorb and distribute loads, and negligible creep characteristics under the stress of the intended application. Another important factor is, of course, the tensile (or cohesive) characteristics of the adhesive which may in turn be affected markedly by humidity conditions and the rate of load application to the joint. Differences in thermal coefficients of expansion of a glue and material being bonded introduce additional problems (22).

All surfaces are generally contaminated with impurities which may include oxide layers, organic deposits, moisture, etc. Purification, or at least a knowledge of surface conditions, is consequently of the greatest importance if strong joints are to be prepared. The moisture content of wood surfaces, for example, determines to an appreciable extent the bond obtained in plywood manufacture (4, 2). The surfaces of metals consist, according to Smekal (23), of a mosaic of small blocks with a number of minute cracks, fissures, or grain boundaries of small dimensions. Considerable import has been given to this roughness of even "smooth" metal surfaces by adherents to the mechanical adhesion school. This emphasis is probably an exaggeration.

Bikerman (24) and Poletika (25) found that the thinner the adhesive film (paraffin wax between brass surfaces) the stronger was the joint. By a simple application of probablility theory Bikerman was able to account for approximately two-thirds of the difference in strength between thin and thick joints. The one-third discrepancy between the values for the thin and thick joints he attributed to crystallization differences in the films.

Summary

A study of adhesion requires a knowledge of three factors, namely, the character of the bond between the adhesive and the surface to which it adheres, the nature of the film and the nature of the surfaces permitting adhesion.

A knowledge of optimal application methods may determine whether a good or poor bond is obtained from an adhesive. However, the differences in bond strengths obtained from adhesives having similar physical properties but dissimilar chemical composition can only be explained in terms of specific adhesion factors. Electrical forces resulting from the dipole moments of polymer polar substituents and ordinary dispersion or forces have been used to explain the strengths of adhesive bonds (26).

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The Preparation of Uniform Films and Their Dependence on the Irregularities of the Base Surface

By Stig Johanson[1]

An important feature in the preparation of uniform films is the base or stock upon which paint is applied. The more uniform the surface of the stock, the more uniform the finished films. Sometimes, however, this fact is overlooked and in spite of a good applicator, films with very divergent thicknesses are obtained.

Brier and Wagner (**1**)[2] give thickness data from films prepared on plate glass with their doctor blade apparatus. A very good grade of plate glass was used for a base, which, however, varied an average of 23.6 μ in thickness. The thickness of the films was about 50 to 150 μ, and the maximum variation for one film was 15.2 μ.

According to Dunn and Baier (**2**), good grade plate glass usually has a variation of about 0.0005 in. (12.7 μ), and films on such panels have a high degree of uniformity. From six films with a thickness of approximately 45 to 60 μ, the maximum variation was about 5 μ. These authors have also made spreadings on cold-rolled steel panels with their applicator. Such panels in long pieces are inclined to give a little more variation than good grade plate glass. Typical values from producing films on eight cold-rolled steel panels are given. The films had a thickness of 35 to 50 μ, and the maximum thickness variation was as great as 30 μ.

It seems that the mechanically operated Bird Film Applicator of Jacobsen and Jensen's construction (**3**) gives a very good result. Films with thicknesses of 40 to 80 μ have been prepared and the maximum divergence was only about 5 μ. It must be assumed that they have used a very good grade plate glass.

The author of this paper has made some comparative spreadings on glass panels of first-rate and second-rate qualities. The apparatus was mechanically operated and of a modified Bird Film Applicator type.

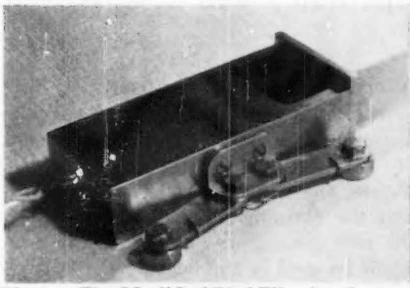

Fig. 1.—The Modified Bird Film Applicator.

Description of the Apparatus

Figure 1 shows the applicator, which is made of brass, 10 by 4.5 by 2.3 cm. The hole containing the paint is 3.5 by 2.6 cm. and the orifice is 50 μ. On each of the two long sides of the applicator there is a pair of wheels, one pair fixed and the other fitted with springs. The last-mentioned pair is seen on the figure. The applicator is held in position on the plate glass by these pairs of wheels. It is drawn over the glass surface by a motor with reducing gears in such a manner that a cord from the applicator is wound round the spindle of the gearing when the motor is started. The most satisfactory speed was found to be 50 cm. per minute. This apparatus is apparently very simple in design and operation, it is easy to clean, and admits the spreading of films of different lengths.

Glass Panels of First Quality

Panels of first-quality plate glass with a thickness of 4.8 mm. were used, and the thickness of the glass and film was measured by means of a micrometer. From each film, 3.5 by 40 cm., sixteen readings were obtained—eight on each side of the film, 10 mm. from the edge of the film. The distance between points of measurement in the row was 50 mm. Table I gives the medium, maximum, and minimum values of the plate glass and film thicknesses. Five different unpigmented drying oils were drawn.

TABLE I.

Panel Film	Thickness, μ			
	Medium	Maximum	Minimum	Maximum Variation
No. 1..	4867	4871	4862	9
No. 1..	48	52	44	8
No. 2..	4873	4880	4861	19
No. 2..	53	58	49	9
No. 3..	4863	4870	4850	20
No. 3..	49	54	45	9
No. 4..	4874	4878	4870	8
No. 4..	48	51	43	8
No. 5..	4867	4874	4864	10
No. 5..	52	56	50	6

The maximum thickness variation of one film was 9 μ.

Glass Panels of Second Quality

The same five drying oils were spread on second-quality window glass with a thickness of 1.8 mm. with the results given in Table II.

TABLE II.—THICKNESS DATA FROM FILMS AND PANELS OF SECOND-QUALITY WINDOW GLASS.

Panel Film	Thickness, μ			
	Medium	Maximum	Minimum	Maximum Variation
No. 1..	1775	1820	1762	68
No. 1..	38	59	29	30
No. 2..	1812	1835	1770	65
No. 2..	46	63	35	28
No. 3..	1785	1830	1750	80
No. 3..	32	50	25	25
No. 4..	1804	1833	1740	93
No. 4..	48	66	30	36
No. 5..	1870	1890	1848	42
No. 5..	36	45	27	18

The maximum thickness variation of one film was now 36 μ.

Conclusion

For the preparation of uniform films it is obvious that first-rate panels as well as a good applicator are necessary. With a mechanically operated applicator, for instance of the Bird Film type, and a first-rate plate glass, films with a maximum thickness variation of 5 to 10 μ can be produced.

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

An Investigation of Radiography in the Range from 0.5 to 2.5 Million Volts[1]

W. W. Buechner,[2] R. J. Van de Graaff,[2] H. Feshbach,[2] E. A. Burrill,[3] A. Sperduto,[2] and L. R. McIntosh[3]

This article describes an investigation in radiography in the range from 0.5 to 2.5 million volts. The work described began in the summer of 1941 as a contribution to national defense by the Massachusetts Institute of Technology and was later continued and extended under contract with the National Defense Research Committee to meet an urgent radiographic need in the war program, particularly for the Navy.[4]

Beginning in 1937, the High Voltage Laboratory at Massachusetts Institute of Technology produced and investigated X-rays of over two-million volts (2 Mev) in connection with nuclear research. Thus, the project could be quickly converted into the exploration of the radiographic possibilities of these penetrating X-rays and into the development of techniques by which they could be applied to the war effort. The expected advantages of the higher voltages were soon confirmed; and, in addition, surprising new advantages were discovered. These results led the National Defense Research Committee to contract with M.I.T. for the development and production of five, compact, 2-Mev X-ray generators. The contract also provided for other work necessarily associated, including the development of new practical radiographic techniques, the servicing of the equipment, and the training of personnel, so that the new generators and their radiation could be used in the field by the Navy[5] with maximum effectiveness.

The special war contribution of this radiographic project lay in the fact that, for the first time, it was possible for the Navy to examine the interior of large numbers of the various types of its heavy explosive weapons, including mines, torpedoes, shells, bombs, and rockets. This nondestructive method of examination of these vital weapons made it possible to improve steadily their construction and performance as they were produced and sent out for use against the enemy. This newly introduced range of radiography was also extensively applied to the examination of the interior of many explosive heavy weapons of a particularly hazardous nature captured from the enemy. Moreover, it was possible to examine quickly and with great precision the interior design of optical and other scientific equipment.[6]

The 2-Mev X-ray generators supplied to the Navy were of compact design, being housed in a pressure tank approximately 4½ ft. in diameter and 10 ft. high. Within the tank, two million volts direct current was provided by an electrostatic generator of the belt type, the compact insulating medium necessary being provided by compressed air or nitrogen at a pressure of 200 psi. The results obtained in the field with these generators have led to a more general realization of the radiographic advantages of higher voltages and to the commercial development of higher-voltage equipment. Since a description of these generators has been published elsewhere[7] and since a more compact industrial design is now available commercially,[8] this article will be confined to the properties of the X-radiation obtained with equipment of this type and the application of such radiation to the problems of radiography.

From the scientific point of view, the important radiographic quantities are the exposure time, the radiographic sensitivity, the radiographic range or latitude, and the definition. These quantities are closely interrelated, and the factors on which they depend can best be determined by using X-ray equipment in which the voltage, tube current, and focal-spot size can be independently varied and accurately measured over a wide range. These requirements are admirably met by constant potential generators of the belt type. The results described below were obtained with both the 2.7-Mev atmospheric-pressure-insulated generator at M.I.T. and the compact units supplied to the Navy.

Production, Absorption, and Scattering of High-Voltage X-Rays

Production:

When electrons having energies of two-million volts are completely stopped in a thick target, an appreciable fraction of their energy is transformed into X-rays. The intensity of these X-rays is a function of the electron voltage, the atomic number of the target, and the angle between the direction of observation and the incident electron beam. Knowledge of the manner in which the intensity depends upon such variables is necessary for efficient use of the radiation for radiography. This dependence has been investigated in this laboratory[9] using the apparatus shown schematically in Fig. 1. The electron beam from an electrostatic generator was made to impinge cleanly upon a target placed in the center of the vacuum chamber. Both the material of the target and its angle with respect to the electron beam could be varied from the control panel. The intensity of the X-rays at the angle

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[1] Some of the material contained in this paper was presented in February, 1946, at the Cleveland symposium on high-voltage radiography sponsored by Committee E-7 of the American Society for Testing Materials.

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[3] Now with High Voltage Engineering Corporation, Cambridge 38, Mass.

[4] A complete account of this research program is given in the *Final Report of the M.I.T. Project in High Voltage Radiography*, OSRD Report No.4488, 7 volumes (June, 1945). The work was conducted under NDRC Contract No. OEMsr-294. The contents of this Report may be of interest and are listed below:

- Vol. 1. Introduction
- Vol. 2. Two-Million-Volt Electrostatic X-ray Generator
- Vol. 3. Design and Developmental Research in Connection with the High Voltage Electrostatic X-Ray Generator
- Vol. 4. Production, Absorption, and Scattering of High Voltage X-Rays
- Vol. 5. High Voltage Radiographic Techniques and Accessories
- Vol. 6. Photographic Aspects of High Voltage Radiography
- Vol. 7. Detailed Drawings of X-Ray Generator Parts

This paper briefly covers the material in Vols. 4 and 5 of this Report. Although the Report as issued is no longer available, microfilm or photostatic copies may be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington, D. C., as Reports Nos. PB-5230 to PB-5236.

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[7] W. W. Buechner, R. J. Van de Graaff, A. Sperduto, L. R. McIntosh, and E. A. Burrill, "Electrostatic Accelerator for Electrons," *The Review of Scientific Instruments*, Vol. 18, October, 1947, p. 754.

[8] From the High Voltage Engineering Corp., Cambridge, Mass.

[9] W. W. Buechner, R. J. Van de Graaff, E. A. Burrill, and A. Sperduto, "An Investigation of Thick-Target X-Ray Production in the Range from 1250 to 2350 Kilovolts," *The Physical Review*, Vol. 71, April 1, 1947, p. 470.

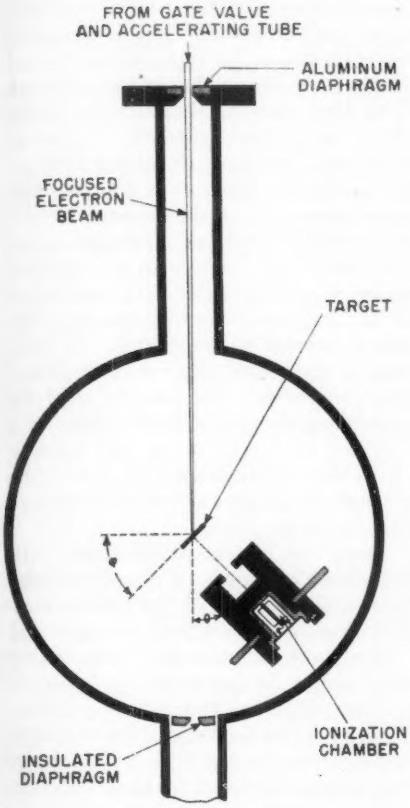

Fig. 1.—Schematic Diagram of Vacuum Chamber for Measuring X-ray Production from Thick Targets.

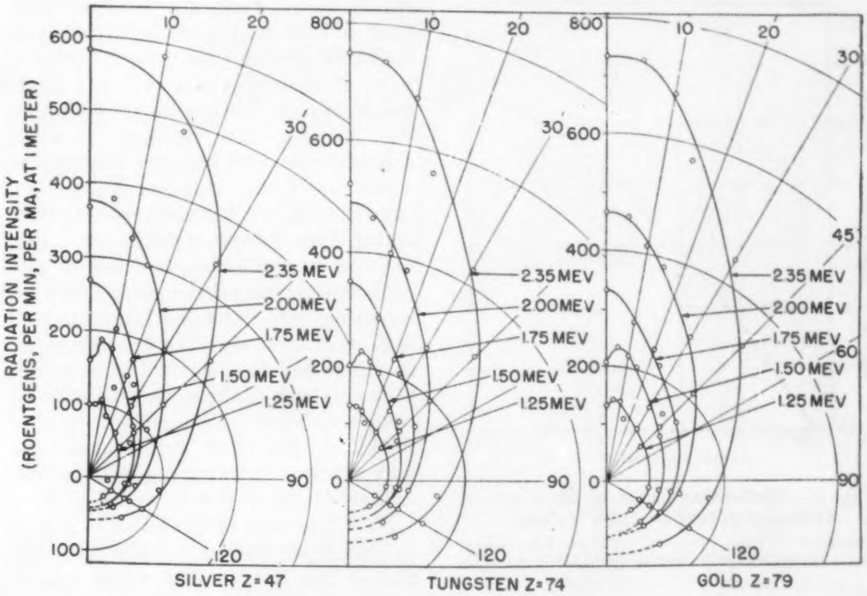

Fig. 2.—Angular Intensity Distribution of High-voltage X-rays from Thick Targets of Silver, Tungsten, and Gold.

θ was measured with an atmospheric-pressure ionization chamber, and both the angle θ and the energy of the electrons in the beam could be accurately measured and varied from the control panel.

Some of the results obtained with this apparatus are plotted in Fig. 2. This set of graphs shows the X-ray intensity in various directions and for several different voltages for silver, tungsten, and gold targets. The intensity scale has been adjusted in each case to make the curves comparable in area; and it is evident that, for a particular target, an increase in electron energy results primarily in an increase of the X-ray intensity in the forward direction. The intensities, as plotted, have all been corrected for absorption in the target and in the material at the ionization chamber.

The results shown in Fig. 2 may be integrated over the entire solid angle surrounding the target to give the dependence of the total X-ray flux emitted as a function of voltage and of the atomic number of the target material. It was found that, for a given voltage, the total flux is quite linear with atomic number, in agreement with calculations based on the theory of Bethe and Heitler. These measurements may also be used to determine the fractions of the incident electron energy which is converted into X-radiation. The result thus obtained gives a value of 7.4 per cent for a gold target at an electron energy of 2.35 Mev.

Absorption:

The absorption of X-rays in this voltage range has been investigated as a function of electron energy, absorbing material, and angle. The half-value layer of steel as a function of steel thickness is shown in Fig. 3, which is a replot from our steel-absorption data. As can be seen from the figure, the softer components of the X-ray beam are rapidly filtered out, so that an equilibrium distribution is quickly established. This indicates that, for thicknesses of steel greater than about 2 in., filtering of the X-ray beam will have little or no effect upon the resulting radiograph. This, together with the fact that the mass-absorption coefficients experimentally determined are approximately independent of the atomic number of the absorbing material,[10] indicates that the radiographic techniques in this voltage range should be very much simpler than those required at lower voltages. This is found to be the case in practice.

The above-mentioned absorption measurements show that, as would be expected, the absorption of X-rays in this voltage range is caused almost entirely by Compton scattering. This makes for a great simplification in dealing with the problem, both experimentally and theoretically. This is confirmed by the curve shown in Fig. 4, which is a plot of the half-value layer of steel as a function of constant potential X-ray tube voltage. The curve is a theoretical one, computed on the assumption that the contribution to the absorption caused by the photoelectric effect and pair production is negligible and that the entire absorption is essentially determined by the Compton effect. It is seen that the experimental values agree very well with the values calculated on this assumption. Since the half-value layer enters exponentially into the equation determining the ex-

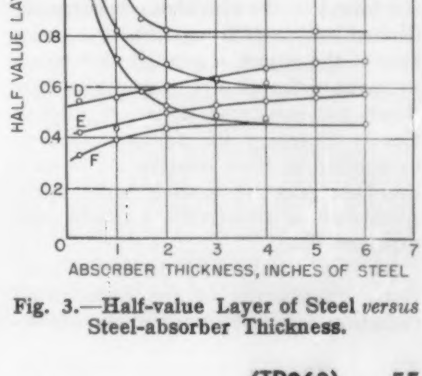

Fig. 3.—Half-value Layer of Steel *versus* Steel-absorber Thickness.

[10] A. A. Petrauskas, L. C. Van Atta, and F. E. Myers, "Measurements on X-Ray Production and Absorption in the Range 0.7 to 2.5 Mev," *The Physical Review*, Vol. 63, June 1–15, 1943, p. 389.

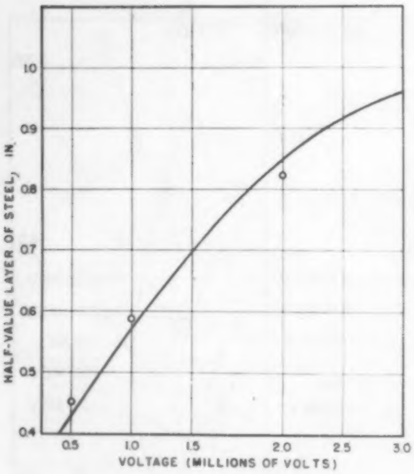

Fig. 4.—Half-value Layer of Steel *versus* Constant-potential Tube Voltage.
Equilibrium total beam values from Fig. 3 are compared with theory (solid curve).

posure time, it is evident that a great reduction in exposure is made possible if the voltage is increased. This is particularly true in the case of heavy metal sections.

Scattering:

If all the X-radiation that passes from the target through the object onto the radiographic film were unscattered, it would be easy to predict the radiographic sensitivity and exposure time from the data presented above on X-ray production and absorption and a knowledge of the film characteristics. Such calculations lead to values of sensitivities that are not approached in practice except under very special conditions. These conditions and the means for obtaining them will be discussed in more detail in a later section.

In the absorption of X-rays in an object, a significant portion of the radiation is scattered by virtue of the Compton effect, as a result of which the object itself becomes a source of secondary X-rays. This radiation emerges from the object with an intensity that depends more on the gross over-all size and shape of the object than on its detailed structure. Since it is only those rays that pass essentially undeflected from the target to the film that can carry the desired information regarding the structure of the object, a quantitative measurement of the relative magnitude of the direct and scattered radiation intensities is necessary for a comprehensive evaluation of their relative importance and their effect upon such radiographic quantities as sensitivity, latitude, and exposure time.

The magnitude of the direct and scattered components of the transmitted radiation was determined in the following manner. First, the total radiation that arrived at a given point (such as might be occupied by a film) behind a mass of absorbing material was determined, using the apparatus shown in Fig. 5. For this purpose, a small thimble ionization chamber was used as a detector rather than an X-ray film, since its response was more reproducible, and it is much more rapid in use. The response of this ionization chamber was calibrated so that its reading could be converted into values of film densities. With this apparatus, the dependence of the total radiation incident upon a film placed in back of the absorbing material could be studied as a function of absorber thickness, generator voltage, and the area of the absorbing material which was irradiated by the X-rays.

Next, the apparatus shown in Fig. 6 was employed to measure the contribution of the X-ray beam which passed directly from the target through the absorbing material and onto the photographic film as a function of the variables outlined above. In this apparatus the film was again replaced by a small ionization chamber that was so protected with lead shielding that only the direct X-ray beam was registered. As can be seen from the figure, the object in which the scattering occurs was supported at some distance from the detector. Since the scattered radiation emerges in all directions with respect to the primary beam, it is evident that its contribution to the ionization-chamber reading with this apparatus was negligible. In addition to the direct-beam measurements, this apparatus could also be used for measuring the scattered intensity as a function of angle, since the detector assembly was pivoted so that it could be rotated about an axis passing through the scattering plate.

From the measurements made with the above apparatus, a simple calculation could be made of the relative contributions of the scattered radiation and of the direct radiation in the blackening that would be produced on a photographic film in the usual position. Figure 7 shows the ratio of the scattered radiation to the direct beam as a function of steel thickness for three different voltages. It is evident that, except for thin objects, the darkening of the film would be caused largely by scattered radiation and that the scattering in the material rather than the absorption coefficient would in general determine

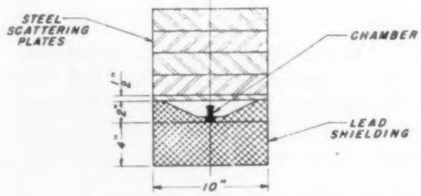

Fig. 5.—Apparatus for Measuring Total X-radiation Arriving at a Point Beneath a Steel Absorber.

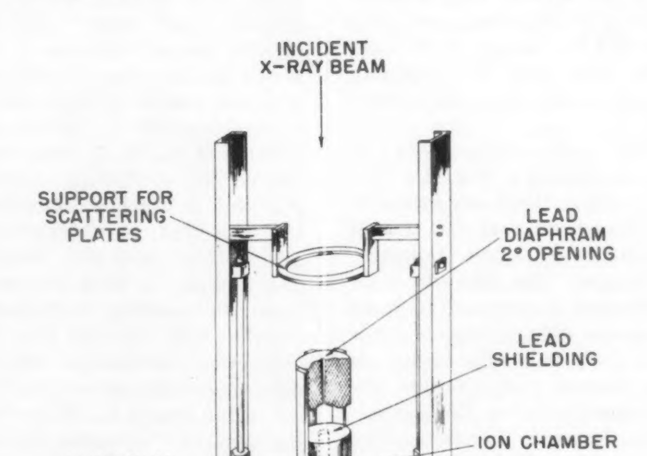

Fig. 6.—Apparatus for Measuring Direct Radiation Arriving at a Point Beneath a Steel Absorber.

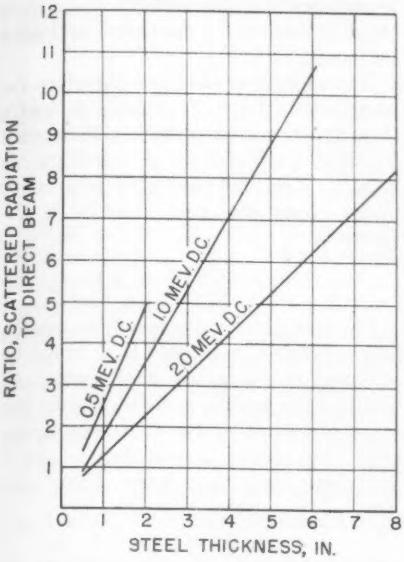

Fig. 7.—Ratio of the Scattered Radiation to the Direct Beam *versus* **Steel-plate Thickness.**

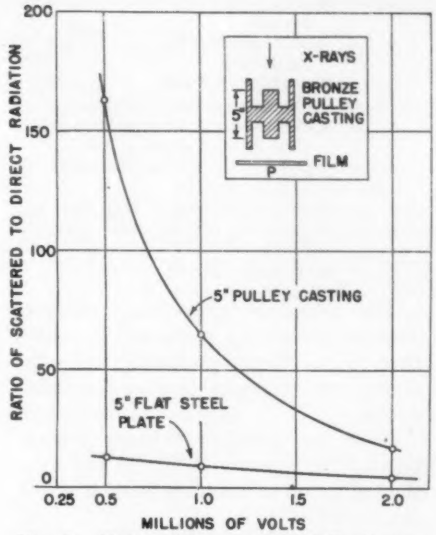

Fig. 8.—Ratio of the Scattered Radiation to the Direct Beam from a Bronze Pulley Casting *versus* **Constant-potential Tube Voltage.**

For comparison, the ratio for flat bronze plate of the same thickness is shown.

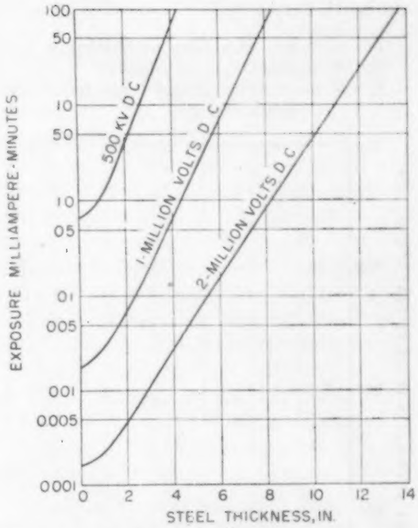

Fig. 9.—Radiographic Exposure *versus* **Steel-plate Thickness.**

These exposures yield a net density of 1.0 on Type A film developed in Kodak Rapid X-Ray Developer, 8 min. at 68 F., with a 24-in. target-film distance.

the radiographic sensitivity. The ratio of the scattered to the direct radiation may be called the "scattering factor." These factors, as determined experimentally, agree very well with those calculated, assuming Compton scattering as the dominant process.

It can be seen that there is a great gain in the reduction of scattering as one goes to higher voltages, the gain being greater in going from 1 Mev to 2 Mev than in going from 0.5 Mev to 1 Mev. The curves in Fig. 7 are for flat plates, which is the simplest geometry from the radiographic point of view. For other geometries, the scattered radiation usually forms an even larger component of the total transmitted to the film; and, in these cases, the advantages of the higher voltages become even more pronounced.

Figure 8 shows some measurements made on the radiation received by a film at a point directly below the central portion of a bronze pulley casting indicated in the figure insert. In such a case the sensitivity, as recorded by the film, is determined almost entirely by the scattering factor, and evidently improves rapidly with voltage in this range.

The effect of the scattering factor on radiographic sensitivity is treated more quantitatively in a later section. Practical methods of reducing the effect of scattered radiation at the film are discussed in detail in connection with descriptions of suitable radiographic techniques at high voltages.

Application of High-Voltage X-Rays to Radiography

In the foregoing sections, the physical characteristics of high-voltage X-rays have been discussed as a background for the results which have indicated the great usefulness of these radiations for industrial radiography. With these basic concepts in mind, it becomes more straightforward to explain the practical aspects of high-voltage X-rays when applied to the field of nondestructive testing. Of primary interest to the radiographer are the following radiographic quantities: penetrating power, exposure, sensitivity, latitude, and definition. Each of these factors, all of which contribute more or less to the legibility on the processed film, are discussed in detail in the sections below.

Penetration and Speed:

The most obvious characteristic of 2-Mev radiation that is useful radiographically is its penetrating power. The small absorption coefficient of the radiation, coupled with the high X-ray intensity, allows radiographs to be made through steel sections much thicker than possible with lower-voltage radiations. In practice, radiographs have been made at the High Voltage Laboratory through 14 in. of steel with reasonable exposure times. As an illustration of the short exposures required with 2-Mev radiation, Fig. 9 shows the trend of exposure with steel thickness for 0.5-Mev, 1.0-Mev, and 2.0-Mev X-rays from an electrostatic generator. The advantage in the use of the higher-voltage radiations for the rapid radiography of objects can be seen in Fig. 10 which shows the ratio of the exposure at 1 Mev to that at 2 Mev as a function of steel thickness. It follows from this comparison that 2-Mev X-rays can be used for production radiography of thicknesses far greater than possible at lower voltages.

Radiographic Sensitivity:

For the successful examination of objects by radiography, the mere penetration of the X-rays through matter is not sufficient. One of the purposes of a radiographic examination is to record details in the volume of the object. Faults developed as a result of metal-working techniques, cracks appearing from undue strains on the object, and checks on the orientation of internal structures after assembly are but a few items of interest to the radiographer. The radiation records this information on the X-ray film as differences in photographic density resulting from the preferential absorption of the beam as it passes through the object. Depending on the absorption coefficient, the scattering from the object, and the location of the film with respect to the object, the radiation is capable of showing small variations in thickness. The sensitivity of the radiation can be defined as the smallest fractional thickness difference (dx/x) that can be perceived on the radiographic film. This fraction is usually expressed as a percentage.

It should be kept in mind that sensitivity, according to this definition, depends somewhat on the sharpness of the boundaries of the defect. This follows from the fact that the eye tends to average the density of an area; and, unless the thickness difference is seen as an abrupt change in film density, the eye is naturally inclined to neglect it.

The following symbols are used in the derivations:

I = X-ray intensity at thickness x,
I_o = initial X-ray intensity,
I_s = scattered X-ray intensity at thickness x,

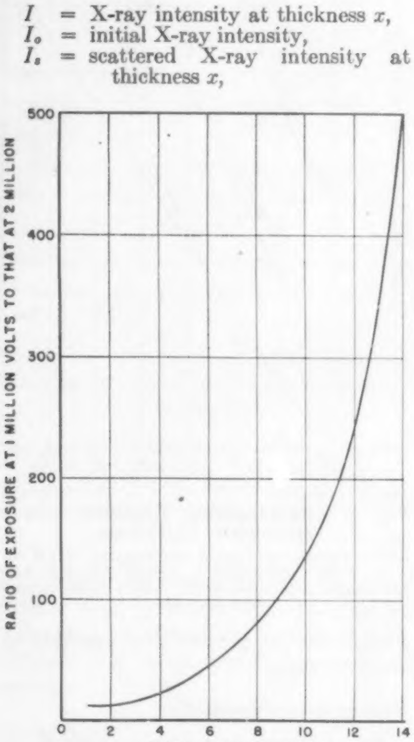

Fig. 10.—Ratio of Exposure at 1 Mev to that at 2 Mev *versus* Steel Thickness.

I_d = direct X-ray intensity at thickness x,
μ = linear absorption coefficient of radiation,
x = absorber thickness,
D = radiographic film density,
G = radiographic film gradient $[dD/d(\log E)]$ at density D,
E = exposure in terms of (intensity) × (time) or (It),
s = radiographic sensitivity (dx/x),
α = minimum observable density difference $[(dD)_{min}]$ and
k = scattering factor.

The most straightforward relationship for sensitivity is the one in which there is no X-ray scattering from the object to degrade the radiographic image.

From the well-known linear absorption law for primary radiation and from the definition of film gradient, it easily can be shown that

$$|s| = \frac{2.3\alpha}{Gx\mu} \quad \text{..........(1)}$$

Equation (1) represents the sensitivity obtainable if there is no scattering present. As can be seen, it depends only upon the absorption coefficient, film gradient, and the object thickness. This relationship means also that, at a particular voltage and film gradient, a constant minimum thickness difference dx will be detected, regardless of the object thickness. From this formula, it is also seen that the sensitivity increases (that is, lessens in quantity) at higher voltages.

The most probable and therefore the most interesting radiographic geometry includes scattered radiation that tends to fog the significant radiographic image. The derivation of sensitivity under these conditions results in the equation

$$|s| = \frac{2.3\alpha}{G\mu}\left(\frac{1}{x} + k\right) \quad \text{......(2)}$$

The first term in the second expression represents the sensitivity that would be obtained in the absence of scattering; whereas the second term represents the fogging caused by the scattered radiation. For thick material both x and k are greater than 1 and therefore the value of $|s|$ tends to $\frac{2.3\,\alpha\, k}{G\mu}$. Thus the degradation in the radiographic sensitivity is mainly dependent on the ratio k/μ. Both of these factors decrease with increasing voltage but in a manner such that a plot of k/μ *versus* voltage displays a maximum at about 0.6 Mev. It evolves that the improvement in sensitivity in going from 0.5 Mev to 1 Mev is small in comparison with the corresponding improvement in going from 1 Mev to 2 Mev. Table I lists the absorption coefficients, the values of k for flat

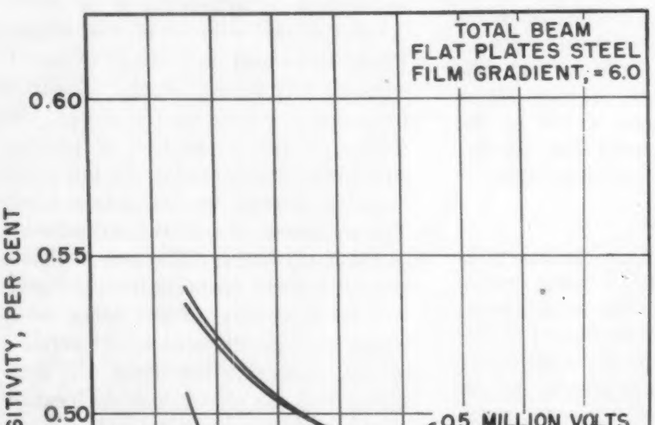

Fig. 11.—Sensitivity (Theoretical) *versus* Steel-plate Thickness for the Case in which Scattering is Present.

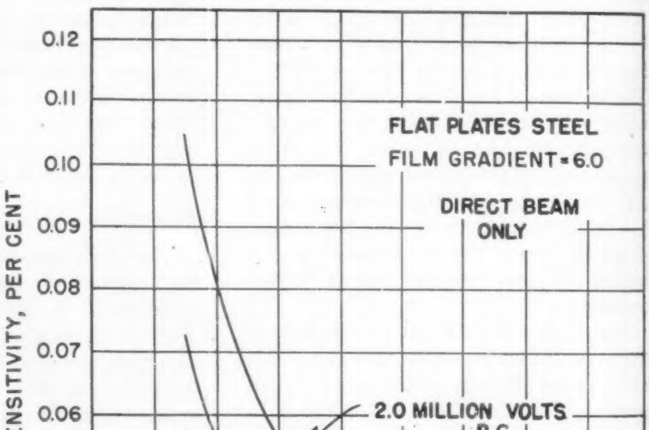

Fig. 12.—Sensitivity (Theoretical) *versus* Steel-plate Thickness for the Case in which Scattering Is Eliminated.

steel plate, and the ratio k/μ for three voltages.

TABLE I.

Voltage (Mev)	μ (inches^{-1})	k (inches^{-1})	k/μ
0.5......	1.53	2.40	1.57
1.0......	1.18	1.78	1.51
2.0......	0.84	1.00	1.19

Using the values listed in the table and assuming an exposure to be made through 5 in. of steel plate at 2 Mev, a sensitivity of 0.46 per cent is predicted on a film developed to a gradient of 6.0. By eliminating the scattered radiation from the object, the sensitivity becomes 0.07 per cent. These calculations are based on a value of 0.008 for α.[11]

The variation of sensitivity with steel thickness is shown for three voltages in Fig. 11 for the case in which scattering is present and is shown in Fig. 12 for the case in which the effect of scattering has been removed. The experimental verification of this formula has been carried out over a wide range of steel thickness, indicating that sensitivities predicted in Figs. 11 and 12 may be expected in practice. For example, sensitivities better than 0.5 per cent have been obtained through 5 in. of steel using normal radiographic procedure. By means of a specially designed Bucky grid (described in detail in a later section), a sensitivity of 0.1 per cent through the same steel thickness has been obtained.

An investigation was made of the dependence of sensitivity on the gradient of the film used. The radiographic films were exposed and developed to a density greater than 3 to assure an approximately constant gradient in the density range of interest. To obtain different values of gradient, the films were developed for various lengths of time, according to the sensitometric information available.[12] By utilizing high-intensity viewing methods and dark-adapted eyes, fairly consistent ultimate sensitivities were read from the films.

According to the formula derived above, sensitivity is inversely proportional to gradient. A plot of sensitivity *versus* 1/gradient should be a straight line, the slope of which is governed by the value of α, assuming constancy of voltage, thickness, and scattering. Figure 13 is such a plot. The solid lines indicate the theoretical predictions, assuming certain values for α. The experimental points lie very well on curves in which $\alpha = 0.0044$ and 0.0035. These two groups of data represent two different experiments and, hence, two different viewing conditions.

[11] C. E. K. Mees, *Theory of the Photographic Process*, Macmillan & Co., New York, N. Y., p. 660 (1942).

[12] E. A. Burrill and W. W. Buechner, "Sensitometry of Radiographic Films Exposed to Two-Million-Volt X-Rays," ASTM Bulletin, No. 148, October, 1947, p. 52.

The fact that all points fall well below the curve for $\alpha = 0.008$ indicates the conservativeness of this assumption. Although no corresponding experiment for the no-scattering case was done, there is no reason to doubt that a similar result would be obtained.

The great improvement in radiographic sensitivity attendant upon the removal of scattered radiation makes worth while the development of radiographic techniques for minimizing the effect of scattering. Methods which have been found to be practical are discussed in a later section.

Radiographic Latitude:

In the radiography of objects in which there is a variation of thickness, it is important to be able to record as great a thickness range as possible with one exposure on a single film in order to minimize the number of radiographs required to examine the object thoroughly. The maximum thickness difference that can be recorded with any detail on a film can be considered the latitude of the radiation. Although latitude is diametrically opposed to sensitivity, it is nevertheless dependent on the same factors that influence the smallest inhomogeneity observable. The apparent paradox existing in the region of 2 Mev (namely, that both sensitivity and latitude improve with voltage) can be most simply explained on the basis that the influence of scattering on both factors varies in a different sense. With sensitivity, the dependence upon scattering is linear; whereas, with latitude, the dependence is essentially a logarithmic term. Thus, sensitivity is affected to a greater extent by scattering than is latitude. The region of 2 Mev is characterized by a much less serious scattering situation than are lower voltages; hence, both sensitivity and latitude are correspondingly better.

At the High Voltage Laboratory, latitude has been defined as the maximum thickness difference that can be recorded on a radiographic film between a density of 3.0 (the practical limit of perceptibility of usual fluorescent viewers) and the density necessary to obtain a specified minimum sensitivity, which has been arbitrarily chosen as 1.0 per cent. The minimum density at which a sensitivity of 1.0 per cent can be recorded is that density at which the gradient of the X-ray film permits that sensitivity, obtained by solving the sensitivity equation for G and substituting 0.01 for s. Since, for low values of density, gradient and density are proportional to each other, the value of density equivalent to the minimum gradient can be obtained.[13]

[13] Eastman Kodak Co., *Radiography in Modern Industry*, Rochester, N. Y., p. 87 (1947).

This density value depends also on the type of film used. The exposure range corresponding to the density difference (minimum density to 3.0) can be read from the characteristic curve for the particular film used.[12] This exposure range can then be used to determine the thickness differential observable by virtue of the exposure-thickness curve presented in Fig. 9. A more straightforward method involves the use of density-thickness curves, given in Fig. 14. These curves, for the various types of film used, give the latitude observable as a function of the minimum density, assuming an upper limit of 3.0.

The variation of latitude with steel thickness for three different voltages is given in Fig. 15, the lower curves indicating the latitudes to be expected when scattering is present, and the upper curves showing the corresponding latitudes when the effects of scattering are removed. It can be seen from these curves that there is an advantage, even at 2 Mev, in considering methods of reducing the effect of scattering from the point of view of improving the thickness range perceptible on a film as well as the sensitivity. Some techniques developed for this reason are discussed in a later section.

Definition:

One of the outstanding features of the electrostatic X-ray generator is that the accelerated electrons are homogeneous in energy and consequently can be focused very accurately by means of a simple annular magnet. The 0.01-in. diameter focal spot obtained with the X-ray generators developed for the Navy pro-

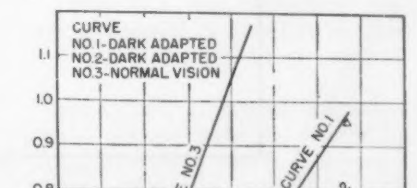

Fig. 13.—Sensitivity (Experimental) *versus* (1/Gradient) for 5-In. Steel Plate at 2 Mev.

Theoretical predictions for various values of α are shown as solid lines.

duces essentially "point source" X-rays. Since radiographs are produced by means of a shadow effect, it follows that each small point, or element of volume, in the object produces as its image on the film a circular disk, assuming that the focal spot, or source of radiation, is round and is of finite size. A radiograph may thus be considered to consist of a great number of such overlapping disks, each one due to a small element of volume in the object. Illustrating this point, Fig. 16 shows the shadow cast by an element of an object when a spot of finite size is used. It is evident that, from this diagram, the smaller the focal-spot size, the better will be the definition

considered the distance from the target to the top of the object, and t the distance from the top of the object to the film (or the object thickness if the film is placed directly beneath the object).

The circle of confusion c can be decreased by increasing the distance d, and this is the usual practice with X-ray sources of finite size. Radiographic exposures are greatly increased by such a technique, however, because of the inverse-square law of intensity. Furthermore, in thick-section radiography, the gain obtained by "backing away" from the target is offset by the thickness of the object, since c is also proportional to t. Thus, the importance of a small

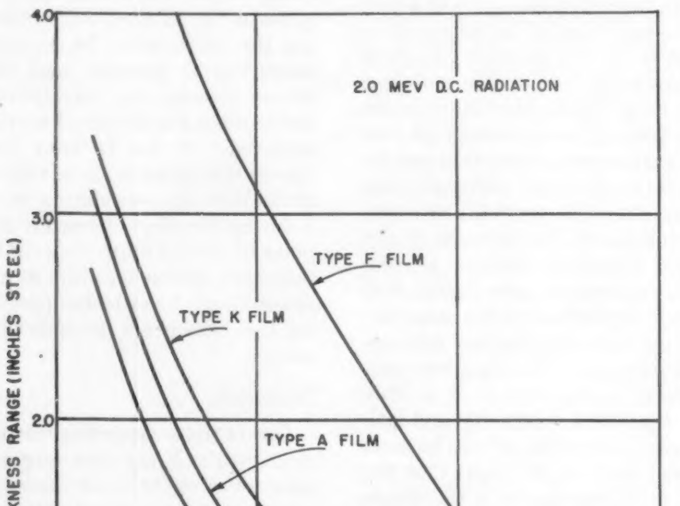

Fig. 14.—Steel-thickness Range Observable on a Film at 2 Mev as a Function of Minimum Film Density.

A maximum density of 3.0 is assumed.

attained on the radiograph. From the geometry of Fig. 16, a relationship between focal-spot size and the shadow disk (circle of confusion) can be obtained.

$$c = s/(d/t)$$

where:

c = diameter of disk or circle of confusion,
s = diameter of focal spot,
d = target-to-defect distance, and
t = defect-to-film distance.

For the worst definition, d is usually

focal spot becomes greater as the thickness of the object radiographed increases and, hence, in general, as the voltage applied across the X-ray tube increases.

The actual resolving power of X-radiation is influenced to a small degree of variables other than the geometrical considerations. The spreading of the effective image due to photo- or Compton-electrons has been investigated. At 2 Mev, computation shows that this effect is quite small, because only the

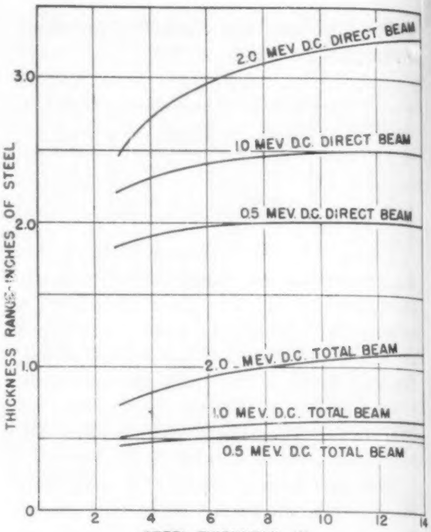

Fig. 15.—Latitude *versus* Steel-plate Thicknesses for Direct and Total X-ray Beam for Sensitivity of at Least 1.0 Per Cent on Type A Film.

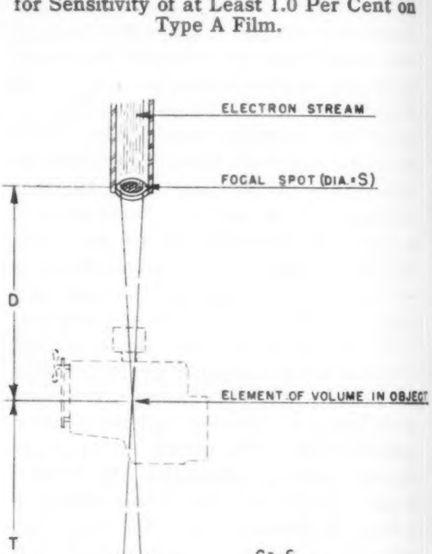

Fig. 16.—Effect of Focal-spot Size on Definition.

extremely short-path-length electrons are absorbed in the photographic emulsion. Those electrons traveling in the forward direction are very energetic and consequently are not very effective in forming the radiographic image because of their penetration through the film. Those electrons propagated at large angles with respect to the direct-beam axis are easily absorbed by the emulsion, because the film lies along the direction

of propagation. Any spreading of the image is mainly due to these latter electrons, which, at 2 Mev, are weak energetically. The path length of these electrons increases with voltage, but in the range of interest the broadening of a very thin line amounts to less than 0.004 in.

The choice of radiographic film is another limit to the resolution obtainable. With Type A film, the emulsion commonly used in this investigational work at 2 Mev, the mean grain size when developed in Kodak Rapid X-Ray Developer is of the order of 0.004 in. in diameter, comparable with the electron broadening mentioned above. With a radiographic geometry in which the distance from target to object is twice that from the object to the film ($d/t = 2$) and with a focal spot 0.01 in. in diameter, the circle of confusion c is about 0.005 in. in diameter. With a normal viewing distance of about 24 in., the film-grain size, electron broadening, and the geometrical diffusion reach about the same limit. Because of the tendency of the eye to integrate small inhomogeneities in the film, however, the practical limit can be considered a d/t ratio of unity.

The matter of the determination of the focal-spot size in the case of high-voltage X-rays presents certain difficulties not encountered at lower voltages. The more penetrating nature of the radiation precludes the use, particularly in the range of very small spots, of the conventional pinhole-camera arrangement commonly used at low voltages. It has thus been necessary to develop a special method for the accurate determination of the size of small focal spots at high voltage. The apparatus constructed for this purpose is shown in Fig. 17. It consists of two heavy vertical lead blocks bolted together in such a way as to form between them an accurately defined vertical slit about 0.002-in. wide. A piece of film is placed horizontally in a hollowed-out region in the top of a third lead block lying stationary under the first two. An electric motor with reducing gear causes the upper two blocks to move slowly back and forth under the target region, progressively exposing the film to the vertical component of the radiation from the target. The width of the darkened line on the film affords, with a slight experimentally determined correction, an accurate measure of the spot size in one dimension. By turning the apparatus 90 deg. about a vertical axis, the width and position of the spot in the other direction can be observed.[14]

The profitable use of small values of d/t with a 2-Mev constant-potential X-ray source allows radiography to be conducted at much smaller distances, permitting greatly reduced exposure times while, at the same time, maintaining an unprecedented degree of definition. The greater sharpness contributes to clearer observation of details in the volume of the object, thereby effectively improving the sensitivity. In a later section, the utilization of "point source" X-rays for precision radiography will be discussed.

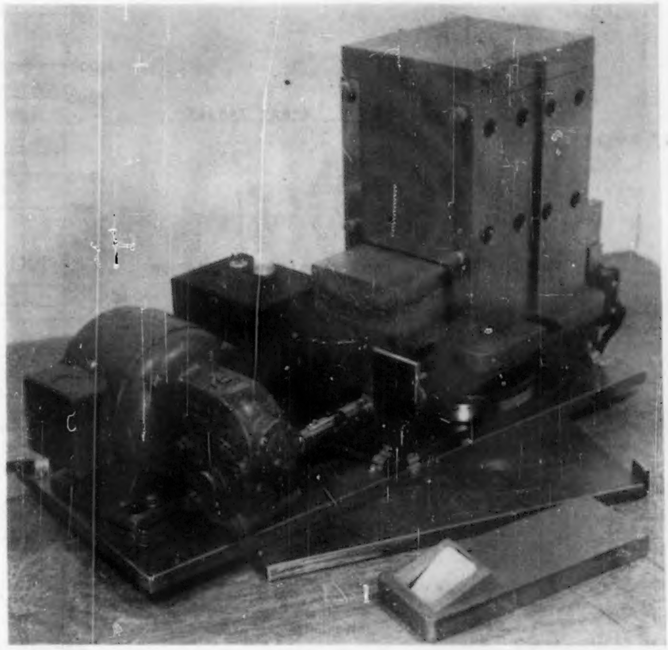

Fig. 17.—Scanning Camera for Measuring Very Small Focal Spots at High X-ray Tube Voltages.

Technique of High-Voltage Radiography

Because of the high degree of latitude and relatively low scattering of 2-Mev X-rays and also because of the very high degree of definition obtainable by means of the small focal spot, radiographic-exposure techniques are basically very straightforward. The usual radiographic setup is shown schematically in Fig. 18. To prevent excessive scattering of radiation from the target, the X-ray beam is defined in the desired direction to a small cone by a thick lead shield. The film holder is protected from back scattering by a barrier of lead about 0.5 in. in thickness. Sheets of lead ranging in total thickness from $\frac{1}{8}$ to $\frac{1}{4}$ in. are normally placed over the film holder to screen out the very soft components of the scattered radiation. Other than these precautions, little else is done to obtain radiographs whose characteristics can be predicted from the curves described earlier in this paper. The problem of blocking and filtration is considered in a later section.

Exposure Calculations:

The technique charts with which the radiographer need concern himself consist mainly of the following:

1. Exposure-thickness curves (see Fig. 9).
2. Characteristic curves of the film used (a discussion of the manipulation of these curves for the desired density on the chosen film is given in another paper).[12]
3. Conversion chart for obtaining equivalent steel thicknesses of other materials.
4. Slide rule for converting the exposures obtained in Item 1 to the distance desired and the target current used.

Of these aids toward obtaining satisfactory exposures without recourse to extensive trial radiographs, little need be said by word of explanation, except in the case of the conversion of thicknesses of materials into equivalent steel thicknesses. Because of the fact that the absorption process predominating in the region of 2 Mev is that due to the Compton effect, the attenuation of the X-rays depends directly on the density of the material to a very good approximation. Thus, to obtain the equivalent steel thickness of an object, the thickness is merely multiplied by the ratio of the density of the object to that of steel to obtain the thickness to be read on the exposure-thickness curve. The contribution to the absorption caused by the photoelectric effect is negligible, and absorption by pair production accounts for about 4 per cent of the total coeffi-

[14] A. Sperduto, "A Method of Determining Focal-Spot Size in High Voltage Radiography," *The Physical Review*, Vol. 69, p. 692 (1946).

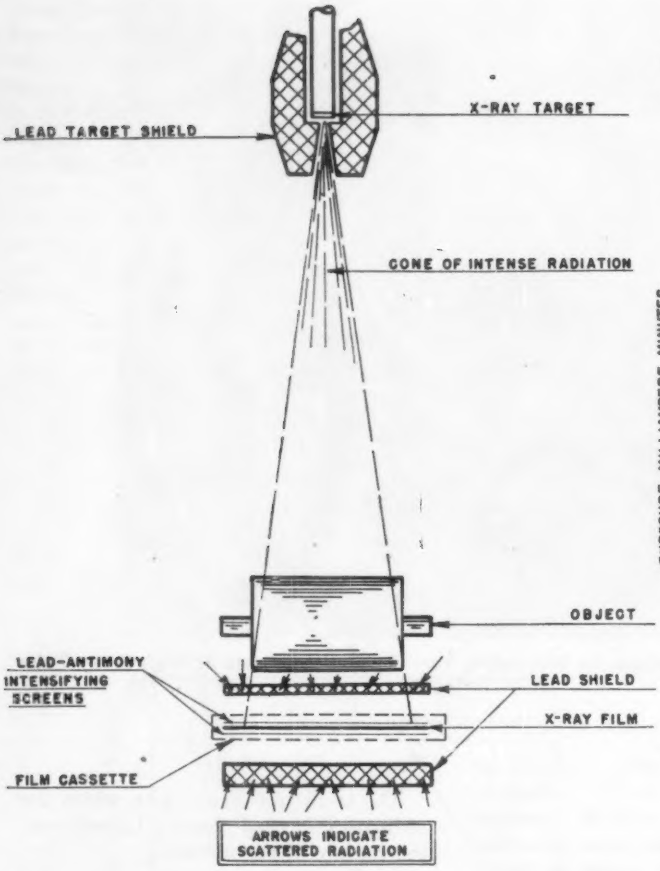

Fig. 18.—Normal Radiographic Setup for 2-Mev Radiography.

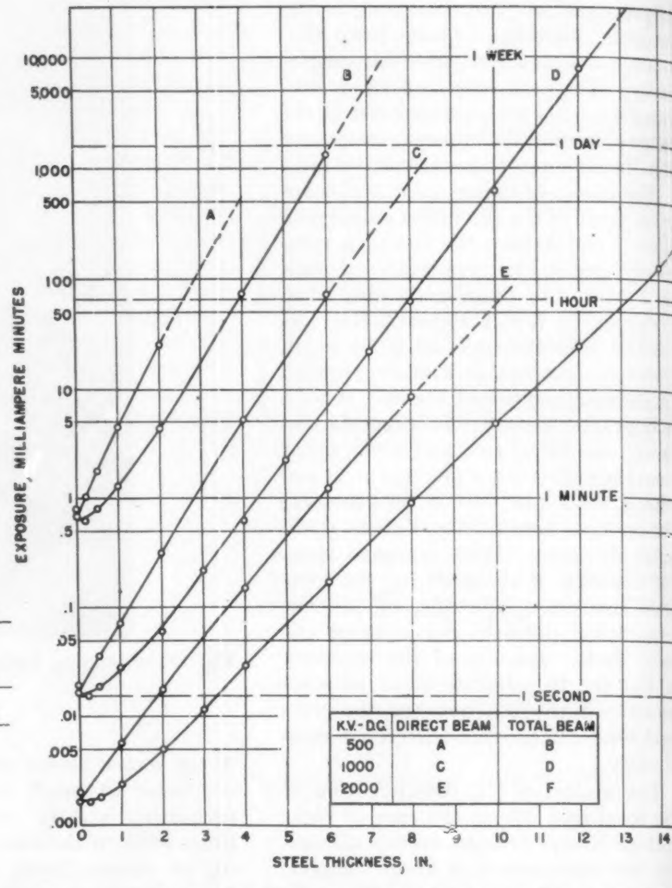

Fig. 19.—Radiographic Exposure *versus* Steel-plate Thickness for Direct and Total X-ray Beam.

Conditions as given in Fig. 9.

cient for steel and about 10 per cent for lead at 2 Mev.

In an effort to simplify the calculation of exposures at 2 Mev, a special slide rule was designed at the High Voltage Laboratory which takes into consideration many of the factors listed above[15]. Although this slide rule was calibrated from radiation measurements beneath flat plates of steel, the exposure calculations are adequate for most simple geometries. The scattering situation in more irregularly shaped objects is more complex and cannot be estimated easily at present. Objects having thin sections directly adjacent to thicker regions offer the greatest obstacle to significant calculations. Unfortunately, a trial exposure is usually necessary to obtain the desired results on the film in such cases. The slide rule, however, does give a basic exposure that is generally not too far from the actual exposure required.

Filters and Blocking:

The X-rays from the 2-Mev electrostatic generator are filtered to a great degree by the target itself. The great penetrating power of the high-voltage radiation permits the use of the transmitted X-ray beam. Since the target of these generators consists of $\frac{1}{4}$ in. of gold, the inherent filtration is equivalent to approximately 0.7 in. of steel. The very soft components of the direct beam are thus absorbed at the source.

A slight improvement in sensitivity is obtained by the use of lead filters at the film, ranging in thickness from $\frac{1}{8}$ to $\frac{1}{4}$ in. depending on the thickness of the object being radiographed. These screens do little else than absorb the soft scattered radiation from the surroundings. The use of filters at the target has not been found to contribute to the improvement of radiographs and has only tended to reduce the intensity.

A glance at the exposure-thickness curve of Fig. 9 shows that, beyond a thickness of 2 in. of steel, the plot at 2 Mev is a straight line. For absorbers greater than 2 in., the material being investigated serves as its own filter. It can be shown that, after 2 in. of steel (or equivalent) have been penetrated, the energy distribution of the radiation remains the same, indicating that additional filtration either at the target or at the film is unncessary but merely serves to increase the exposure.

At 2 Mev, there is no necessity to block irregularly shaped objects with lead shot by immersion in liquids of high density or by similar methods serving to decrease the thickness range. This follows from the great range of latitude and low-scattering characteristics of 2-Mev X-rays.

Elimination of Scattered Radiation:

In the case of objects of severe geometry, that is, those which include thick sections adjacent to thin regions, it is advantageous to minimize the effects of scattered radiation from the object. The scattering factor, k, discussed in the section on scattering of high-voltage radiation, is greatly dependent not only upon voltage, but also upon object geometry. The results of measuring the scattered radiation from a bronze pulley casting (shown graphically in Fig. 8) indicate that the ratio of scattered to direct radiation at 0.5 Mev is about 166 (compared with 12.0 for flat plates), and it decreases quite rapidly to 2 Mev where it is 16.6 (compared with 5.3 for flat thicknesses). In this extreme case, the great advantage of 2-Mev radiation can be seen very clearly. For any quantita-

[15] Futher details on this slide rule are available at the High-Voltage Laboratory at M. I. T.

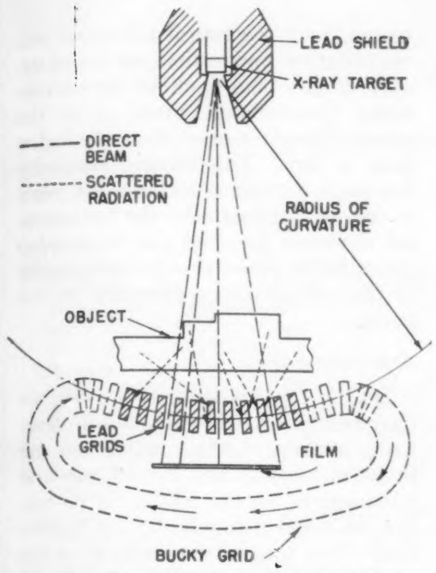

Fig. 20.—Principles of Operation of High-voltage Bucky Grid.

tive examination of such an object, the higher voltage would necessarily have to be used to detect discontinuities smaller than 2 per cent of the total thickness. This geometry is of course extreme, but it serves to illustrate that, regardless of the shape of the object, the higher voltage can allow a more thorough examination to be made.

Two methods for reducing scattered radiation have been devised at the High Voltage Laboratory which have yielded satisfactory results under certain conditions. The technique of projecting the X-ray shadow for eliminating some scattered radiation consists of separating the object from the film, thereby obtaining an enlarged image on the film. The success of this method depends on the fact that the scattering has as its origin the volume of the object; whereas the direct beam originates from the target. Any separation of the film from the object causes a greater relative decrease in scattered intensity, as compared with the intensity of the direct image-carrying beam. Sensitivities of the order of 0.25 per cent through 5 in. of steel plate have been observed using this technique. Comparing this figure with the 0.5 per cent normally expected when no attempt is made to eliminate scattering, it can be seen that a substantial improvement in radiographic quality can be had. The practicability of this technique depends upon the use of "point source" X-rays. Otherwise, the radiographs so obtained would be greatly diffused and would thus contain less information than those made directly against the object.

The exposures, using this technique, are increased over the normal exposures for two reasons. The separation of the film from the object, assuming that the object remains at the same position with respect to the target, increases the exposure because of the inverse-square law of intensity. The removal of the scattered radiation, which carries no information but merely blackens the film indiscriminately necessitates an increase in exposure. The resultant exposure would lie somewhere between the curve for "total beam" and that for "direct beam" as shown in Fig. 19. It has been shown that the scattered radiation accounts for the difference between the two curves at each voltage. The elimination of scatter at any voltage would increase the exposure but with the result that the exposure of the film would be more significant, because of the greater fraction of image-carrying radiation. The relative increase in exposure is less at 2 Mev than at lower voltages because the scattering contribution is less.

Another method of reducing scattered radiation at the film is the use of a specially designed high-voltage Bucky grid. The principle of operation of this device is to prevent stray radiation from hitting the film by means of a series of lead grids passing continuously over the film. Figure 20 is a diagram of the function of this apparatus, and Fig. 21 shows a photograph of the unit constructed at the High Voltage Laboratory for use at 2 Mev. The grids are so arranged that only the X-rays propagated radially from the target are allowed to pass through to the film. This modification of a device familiar to workers at lower voltages has been used to obtain radiographs exhibiting sensitivities of about 0.1 per cent through 5 in. of steel plate. This degree of sensitivity approaches the ultimate value (0.07 per cent) predicted for the case in which there is no scattering.

The exposure increase attendant upon the use of the Bucky is caused by two factors. The lead grids permit only half the film to be exposed at any instant; hence, an increase of a factor of 2 in the exposure is required, because of geometrical limitations of the apparatus. The elimination of scattering is very nearly total, and exposures are read on the curve for "direct beam" in Fig. 19. To a greater degree than in the projection method, the elimination of scatter removes the fogging radiation that yields a deceptively shorter exposure by virtue of the general blackening of the film. The disavantages of the Bucky grid are that the object must be of regular geometry and that unabsorbed radiation must not strike the apparatus. The reason for both of these qualifications is that, because of the mass of the Bucky grid, it can become a scattering source itself if the radiation intensity impinging upon it is sufficiently great in comparison with the intensity reaching the film through the object.

Discussion

The characteristics of 2-Mev X-radiation from the electrostatic generator combine to make radiography at this voltage very versatile. The fundamental investigations described in this paper reduce the problems of high-voltage radiography to simple techniques. In summarizing the results of this research, the following facts are outstanding:

1. The penetrating power and intensity of the radiation permit production

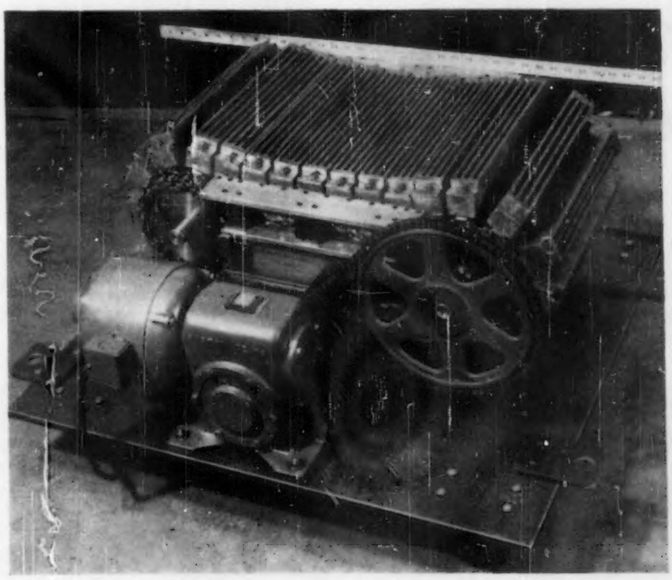

Fig. 21.—Bucky Grid Designed for Operation at 2 Mev.

radiography of sections up to 8 or 10 in. of steel and quantitative examination of objects as thick as 14 in. of steel and greater.

2. The sensitivity and latitude, in combination with the high degree of definition, permit analytical investigation of the volume of the object. Inhomogeneities and internal structures are revealed in more detail both because of the small focal-spot size and because of the inherent contrast of the radiation.

3. Objects that have an unfavorable geometry can be more effectively radiographed at 2 Mev than at lower voltages, because the scattering factor is much less for the high-voltage case. The problem of minimizing scattered radiation is more easily solved with 2-Mev "point source" X-rays because the scattering is less than at lower voltages and because of the small focal-spot size.

4. Stereoscopic radiography can be very effectively conducted at 2 Mev by virtue of its penetration and because of a small focal spot. A natural stereoscopic effect is more pronounced in thick sections. By recording the details of the object with more sharpness, the confusion usually met with the blending of stereoscopic radiographs is minimized.

Some of the applications of 2-Mev X-rays to precision radiography have been discussed in another paper.[16] It is found that the properties of this radiation are such as to yield radiographs of high quality through objects in which the orientation of internal parts must be ascertained with precision.

There are some advantages to the use of higher-voltage X-rays. X-rays of energy higher than 2 Mev are useful in obtaining increased penetrating power and intensity and lessened scattering. The gains over 2 Mev are not, however, so remarkable as the improvements obtained in going from lower voltages to 2 Mev. Except for the radiography of very thick sections which, at 2 Mev, require several hours' exposure, the use of higher voltages has no outstanding radiographic advantages.

The downward trend of k/μ decreases with increasing voltage as the Compton effect becomes less important and as the total absorption coefficient approaches a minimum value. Latitude continues to increase with higher voltages but without a corresponding increase in sensitivity. The production of X-rays becomes more and more pronounced in the forward direction, tending to limit the useful cone of radiation. The spreading of photo- and Compton-electrons in the photographic emulsion tends to prevent the attainment of the fine definition attending 2-Mev precision radiography. At voltages greater than about 10 Mev, the absorption coefficient for materials such as steel increases with voltage. Although the scattered X-rays may not represent so large a fraction of the total radiation, the penetration of the fogging radiation (which has lower energy) may be greater than that of the primary beam. The problem of protecting against this scattering would be more difficult to solve than at lower voltages.

In reviewing the literature of radiography at lower voltages, it appears that 2-Mev radiography is on a very firm foundation, because of the basic information obtained regarding the radiographic qualities of high-voltage radiation. The quantitative examination of the characteristics of the radiation of interest to the radiographer; the theoretical consideration of the fundamental processes involved; and the development of formulas to explain the magnitude of the effects observed all serve to place 2-Mev radiography on a very well-established basis.

Conclusion

In the 2-Mev range, the absorption of X-radiation is fortunately dominated by the Compton process alone. For this reason, both theoretical treatment and quantitative application are considerably simpler than in either the conventional lower-voltage range or in the newer voltage range substantially higher than 2 Mev. This relative simplicity has made it possible within a few years to survey systematically the fundamental processes involved and to develop quantitative procedures for radiography in the voltage range discussed in this paper.

Acknowledgments:

During the course of this work, we have received much valuable help from many sources, of which only a few can be listed below. The Project was first administered for the NDRC by its Section D-3 and subsequently by Section 17.2. The nontechnical aspects of the work were administered for M.I.T. by its Division of Industrial Cooperation. We wish to express our appreciation to Captain C. S. Piggot, USNR, for his interest and cooperation, which greatly increased the effectiveness of the work for the Navy. We are also grateful for the helpfulness of the other Navy personnel with whom we were associated.

The Project owed much to the many individuals who shared in the scientific and technical aspects of the work. We greatly appreciate the important work of E. N. Strait, H. J. Rowland, R. C. Urquhart, and John A. Hornbeck during the periods when they were associated with the Laboratory. The skillful work of E. W. Nickerson and W. A. Tripp was of great value throughout the course of the Project. We are indebted to the counsel of H. H. Lester, Chief Physicist, Watertown Arsenal, C. G. Lutts, Materials Engineer, Boston Navy Yard, and John T. Norton, Metallurgical Department of M.I.T.

We greatly regret that lack of space prevents acknowledgments to the many other individuals and organizations from whom we received much generous help.

[16] E. A. Burrill, "Precision Radiography at Two-Million Volts," *Nondestructive Testing*, Vol. 6, No. 2, Fall, 1947 p. 42.

ASTM Bulletins—1948

Subject Index Papers, Reports, and Articles

Index to Authors of Technical Papers
1948 ASTM Bulletins

While the Author Index does not list authors according to alphabetic sequence and the titles of some of the papers are condensed, it is believed the information as presented will be of service. Further details are given in the Subject Index.

Errata—Wyzenbeeck Test Meter

Our attention has just been called to a few errors in the paper by Tanenhaus and Winston on "Report of the A.S.T.M. Task Group Studying the Wyzenbeek Precision Wear Test Meter," published in ASTM BULLETIN No. 154, October, 1948, p. 74.

In Fig. 2, the note under the caption should have indicated the breaking strength as 121.3 lb.

Identifications of the various sections of Fig. 4 on page 78 were left off. Tests on the left-hand group of Herringbone specimens were made using No. 0 emery paper, on the right-hand group using Aloxite aluminum oxide cloth. The specimens are so arranged in each group so that the left vertical row is for Warp, the next row for Filling, the next row Warp Folded, and the fourth row Filling Folded. The horizontal rows are arranged to represent, from top to bottom, tests made by Company B, C, D, E, F, and K, respectively.

In notes *d* and *e* under Table VI, p. 80, the equations for upper and lower control limits should have shown the last value as a fraction: $2\bar{\sigma}/\sqrt{28}$ and $2\bar{\sigma}/\sqrt{56}$.

Elementary Mechanical Vibrations

A RECENTLY published book on the subject of Elementary Mechanical Vibrations, written by Austin H. Church, Professor of Mechanical Engineering at New York University, is based upon courses given at New York University to various groups. It is written for those who have had the usual engineering courses in mechanics and calculus. With this background, little difficulty should be experienced in understanding the subject matter. Extensive use of examples has been made to clarify the text, and at the end of each chapter problems (with answers) are given by which the reader may test his grasp of the material treated.

The several chapters of this handbook cover Introduction; Undamped Free Vibrations—Single Degree of Freedom; Undamped Forced Vibrations—Single Degree of Freedom; Damped Free Vibrations—Single Degree of Freedom; Damped Forced—Single Degree of Freedom; Undamped Vibrations—Two Degrees of Freedom; Multimass Torsional Systems; Equivalent Torsional Systems; Multimass Lateral Systems and Balancing. The book is about 200 pages and is well illustrated. It is published by Pitman Publishing Corp., 2 W. 45th Street, New York City, at a list price of $3.25.

Study of Engineering Registration Laws

A. M. SARGENT, Doctor of Engineering and Registered Professional Engineer of Detroit, has published an interesting and informative "Study of Engineering Registration Laws." This analysis embodies a rather complete study of the registration laws and their general implications in each of the 48 states, in the territories of Alaska, Hawaii, Puerto Rico, and in all but one of the Canadian provinces. The author, a Past-President of the American Society of Tool Engineers, and General Manager of the Pioneer Engineering & Manufacturing Co., has studied the subject at close range for many years, and this is the first such work which has appeared. It is the purpose of the discussion to examine objectively the public necessity for such laws, to call attention to the effects strict enforcement would have upon industry and society in general, to discuss the general requirements of the laws and to point out some of the potentially dangerous practices open to administrative officials who are granted broad and vaguely defined powers.

This 60-page booklet ($8\frac{1}{2}$ by $5\frac{1}{2}$ in., paper bound), issued on a nonprofit basis, can be obtained from Dr. A. M. Sargent, 19669 John R. St., Detroit 3, Mich. Prices are as follows: single copy, $.75; 10 copies, $6.75; 50 copies, $30.00; 100 copies, $52.50; 1000 copies, $450.00; carrying charges prepaid.

Symposium on Spectroscopy

THE Society for Applied Spectroscopy has announced a "Symposium on Spectroscopy," to be held on January 4, 1949, at the Lecture-Hall, Old World Building (Socony-Vacuum Training Center), 65 Park Row, New York City, at 8:00 p.m. The speakers and topics are as follows:

Dr. Colon of Merck & Co., "Spectrophotometric Determination of Benzyl Penicillin"

Mr. Wiley of the National Lead Co. Laboratories, "A Vibration Isolation Mounting"

Mr. North of the Titanium Pigment Laboratories, "Addition of Silver Salts for Intensifying Impurities in Titanium Spectra"

Mr. VanDien, Consulting Engineer, "The Fluorine Band Spectra."

Professor Henry H. Hausner, Chairman of the Public Relations Committee, Society for Applied Spectroscopy, may be addressed at New York University, University Heights, New York 53, N. Y.

Standardization—Dynamic

THAT Standardization is not static, but on the contrary is dynamic, is the conclusion of an article by Lester Benoit, General Secretary, Manufacturers Standardization Society of the Valve and Fittings Industry, in the June issue of *Industrial Standardization*. The concluding paragraph of this article which had the title "Valve and Fittings Industry Uses Standards for Savings" is as follows: "It would seem that in an energetic industry such as ours, which has worked on standardization problems for so many years, the job should have been completed long ago. Exactly the opposite is true. In spite of the fact that MSS has the largest membership at any time in its history and has the greatest number of technical committees working, we still have one of the largest programs ahead of us, proving again a statement once made by D. P. G. Agnew and one which I am fond of repeating—"'Standardization is not static—it is dynamic.'"

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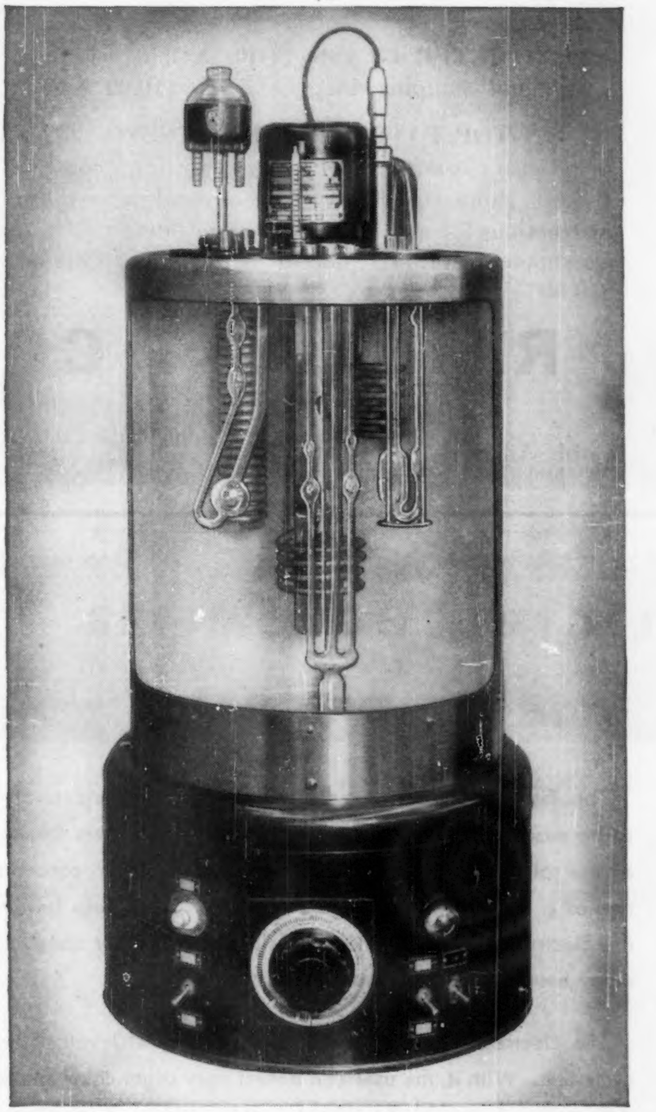

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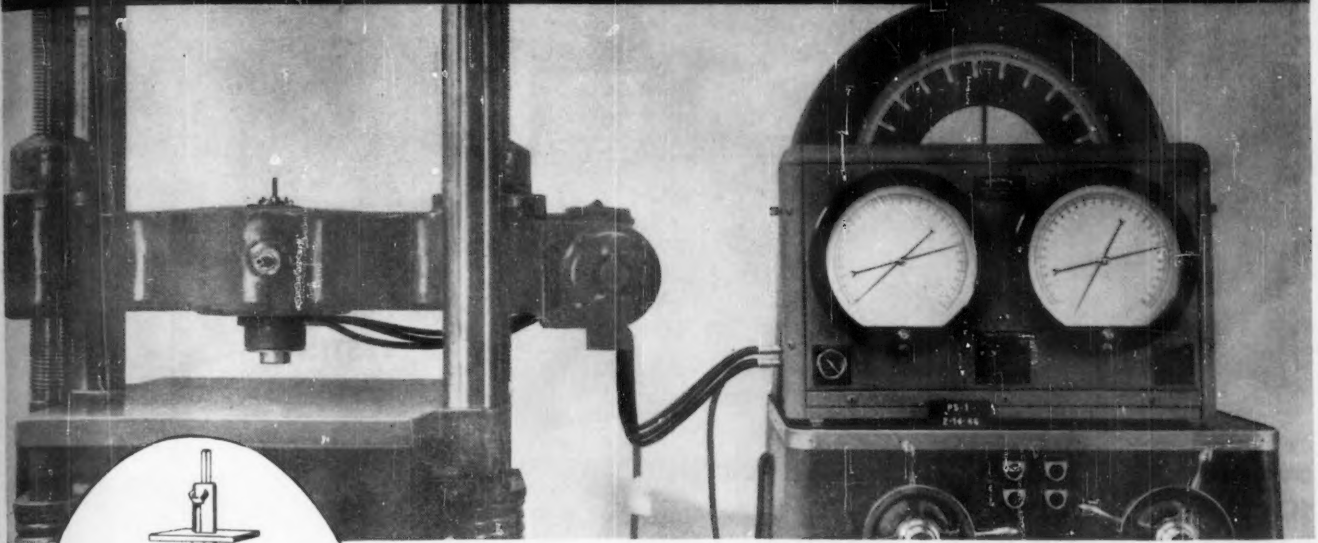

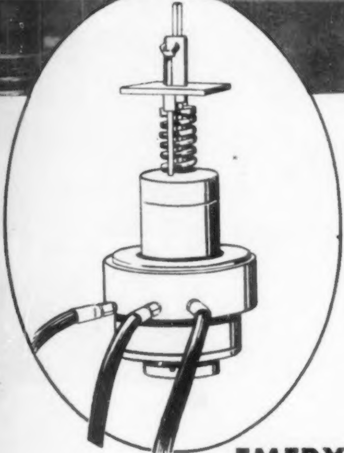

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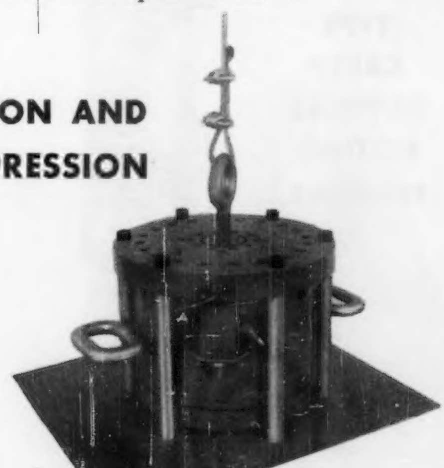

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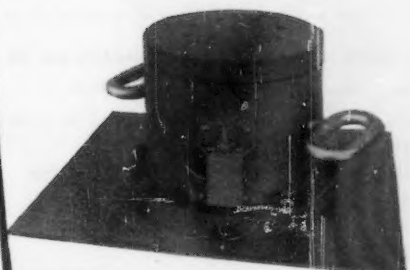

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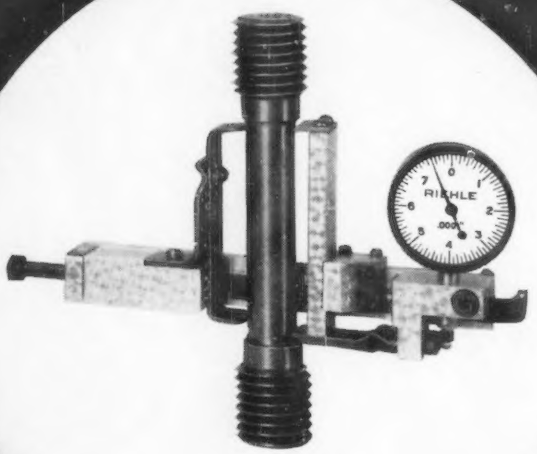

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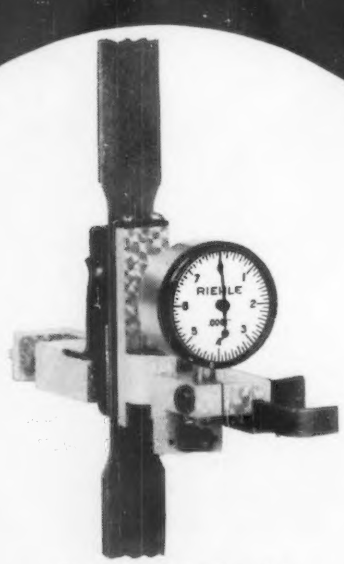

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